The Impact of Hybrid Learning on College Students' Attention

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ABSTRACT

Hybrid Learning is being adopted at many universities in order to accommodate the evolving Covid-19 pandemic guidelines. It combines in-person learning with online learning to give students flexibility for how they would like to consume their college education. Prior to the pandemic, college courses at the University of California at Berkeley were conducted primarily in-person with a few larger courses recording their lectures for re-watching online. At the peak of the pandemic beginning in March 2020 when all in-person classes were halted and moved online, students were required to quickly adapt to remote learning. As the pandemic restrictions began to ease by Fall 2021, an increasing number of courses were offered in a hybrid learning format. However, there is a lack of research in comparing the attention spans of students who join the same class in person versus synchronously online. In this research design article, I examine existing research on students' attention spans during exclusively in-person lectures or exclusively online lectures. From a cognitive science perspective, I seek to explore how we can utilize electroencephalography (EEG), a non-invasive neuroimaging device, to measure and compare the attention levels of students who attend a lecture in person and students who attend the same lecture online. Through this study, professors of hybrid classes may use the data acquired through neuroimaging in order to test and find techniques that can help them improve engagement with their students participating synchronously online.

Introduction

With the Covid-19 pandemic easing, college campuses have completely or partially reopened for in-person classes. Distance learning became the main mode of learning during the semesters of Spring 2020 to Spring 2021. Many students found it hard to concentrate in their online classes due to having their phones and other distractions around them (Guijosa, 2019). One study concluded that brains are not designed to learn from a computer screen, but instead learn better from human interaction in a physical space (Eggers, 2020). On the other hand, some students have reported that online learning has been beneficial to them, claiming that it was helpful to have recorded lectures and flexibility of class times (Hess, 2021). Beginning with the Fall 2021 semester, schools across the United States have been able to transition back, at least to some degree, into in-person learning. However, because not everyone feels ready to fully transition to in-person learning and some do not feel comfortable coming to large classes, schools have decided to implement a new mode of learning. This new mode of learning called "hybrid learning" allows for classes to be held in person, but also be streamed live online for students to watch elsewhere or even recorded for students to watch later. Many professors from the University of California at Berkeley (UC Berkeley) utilized this method of learning for the Fall 2021 semester. With a population of 42,327 students, the university decided that they could not safely hold classes fully in-person, so professors were able to choose their preferred method of teaching as long as it followed Covid safety guidelines.

Research on students' attention during in-person lectures and online lectures has been conducted in the past for the purpose of improving student engagement. Using neuroimaging techniques, researchers can track a person's attention by monitoring brain waves that come from the frontal region of the brain. Previously, these techniques have

been successful in determining whether certain teaching styles keep students mentally engaged and can tell when students begin to disengage and stop paying attention to lectures. The rise of the new hybrid mode of learning leads to the question of "is hybrid learning successful in keeping students watching in-person as well as online similarly attentive?" While studies have been conducted measuring students' attention in classrooms that are either in-person or online, there is a lack of research that directly compares the attention of students who watch a lecture in person and students who watch the same lecture online. To test whether students enrolled in hybrid-style classes pay more attention in the online portion or in the in-person portion, I will use an electroencephalography (EEG) device, a non-invasive neuroimaging device, to track attention levels in students. I hypothesize that the in-person group will pay more attention in class due to the comparatively impersonal nature of online learning platforms. If my hypothesis is correct, then it would tell us that hybrid learning is not as successful as it can be. The teaching methods of the lecture might need to be altered for it to keep students paying attention both in-person and online. This research is useful because as the pandemic continues to evolve, we may need to, and even want to, keep the hybrid format of learning for the foreseeable years ahead. The results of this research can be used to implement ways to improve this format of learning in the future to make online learning more productive for students. In addition, other colleges in the United States may be able to use UC Berkeley as a model for effective hybrid learning.

Literature Review

Students' Attention During In-Person Lecture

Attention is the cognitive process that selects certain stimuli to concentrate on and certain stimuli to ignore. The human brain is wired so that attention is both limited and selective. Attention being limited means that the brain can only retain so much information. Some researchers claim that the average attention span for a student is 10-15 minutes. However, researchers Karen Wilson and James Korn found in their research, "Attention during Lectures: Beyond Ten Minutes," that students' attention mainly depends on three factors: the lecturer, the format of the lecture, and how much that student likes the topic. When the brain is being "selective," it directs awareness to relevant stimuli while simultaneously blocking out irrelevant stimuli. In this process, the connected receptors and dental processors are directed towards a specific memory in the environment. Thus, it elicits a response at the targeted goal (Isaac, 2021). Since the rise of technology, it has become harder to ignore distractions. One study, "College Students' Cell Phone Use, Beliefs, and Effects on their Learning," by Anastasia Elder, found that students who used their phones during lecture did not retain as much information as those who did not use their phones. Although the study did not conclude whether the distraction affected the students' scores, it did claim that distractions could potentially impact their memory of the course content in the future. In 2014, researcher Sam Goundar conducted a study called "The Distraction of Technology in the Classroom" which explores the impact of technology on students during lectures. Students reported that they did find themselves using their phones for non-academic purposes during lecture when allowed to use technology. Attention being limited and selective is relevant to this research because after the switch to online learning, students have found their attention to decrease even more due to distractions at home, especially their phones. With technology being one of the main distractions within the classroom, it is now even more of a problem for students attending lectures online because their phones are even more accessible when at home.

Transition from Online to Hybrid Learning

For an approximately 18-month period beginning in March 2020, online learning had replaced in-person learning at most schools in the United States. The main platform for online learning is Zoom, which provides video-chat services through a cloud-based software program. Zoom was ideal for online learning because it could be used for lectures, meetings, and just chatting with friends. In June 2020, towards the beginning of the pandemic, Zoom saw an increase

in sales by 169% from the previous year and still continues to see growth and success (Sherman, 2020). Zoom proved to be a very useful platform for online learning, however it did come with its downsides. Many students lacked the motivation to get ready for the day like they would for their in-person classes. Due to asynchronous and online learning, students lost their normal schedules and their "regular lives" (Eggers, 2020). In addition, one study from Kent University found that students felt freer to multitask while attending online class. As seen in the previous section, students who use their phones while in class are less likely to pay attention and retain lecture content. The increase in distractions that come from online learning supports the argument in favor of in-person learning. To support this claim, researchers Nitza Geri, Amir Winer, and Beni Zaks found that online video lectures lose engagement after around 15 minutes of no interactivity between instructor and students. They suggest for practitioners to make their lectures more interactive in order to increase and maximize the attention span of their students.

As of Fall 2021, UC Berkeley introduced a new mode of learning in addition to in-person classes and online classes. This format of classes, which combines online lectures and in-person lectures, is called "hybrid learning." This allows for students to have the option to attend the in-person lecture, or watch it online. This was done to alleviate concerns about the spread of Covid-19 cases while still bringing back all the students who wanted to return to campus. Hybrid learning, however, was not implemented as extensively as students had hoped. In an article for The Daily Californian, UC Berkeley's student newspaper, the writer interviewed students who expressed discontent with the current system. Many students wished that there were more lectures that were recorded, and some wished that more of their classes were conducted in-person (Raps, 2021). Although not every class could be taught in the hybrid mode of learning, the transition to hybrid learning became necessary when there was an uptick in Covid-19 cases over the summer. In general, smaller schools moved away from online learning sooner than did large campuses. UC Berkeley had not announced the full return to in-person classes until the Spring 2022 semester. UC Berkeley Chancellor Carol Christ had stated that professors should still be flexible due to uncertainty (CBS News, 2021). Although there were some downsides to online learning, students still appreciate the flexibility of hybrid learning because it allows them to get the best of both worlds. Given the uncertainty of the pandemic, the mixed opinions on online learning, and the desire for students to want to go back in-person, it is important to adapt to new modes of learning that can accommodate all of the above. This research paper will explore if giving a lecture to students in person and the same lecture to students online will result in similar levels of attentiveness.

Electroencephalography (EEG)

It is common for teachers to believe that students are not paying attention in class when they receive poor test scores. However, it is not always a true indicator of poor attention. Bad grades could be a result of insufficient studying, an extraordinarily difficult test, or just a bad day. Attention can be measured in several different ways. An electroencephalography (EEG) is a way to measure attention, memorization, and engagement. One common use for EEGs is measuring arousal from stimuli in the brains of people with ADHD (Isaac, 2021). For this intervention method, also known as neurofeedback, electrodes are placed on the scalp, non-invasively, and then a computer records the brain's electrical activity and tracks them as waveforms. The results of an EEG on people with ADHD typically show low levels of arousal. Then, doctors can use this to train the patient and try to increase levels of arousal in the brain. For the purpose of this study, an EEG will be used to measure attention. This works because the brain activity that occurs in the frontal lobe is associated with attention, as well as other functions like personality, emotion, and creativity (Isaac, 2021). Research published by the Journal of Medical and Biological Engineering states that "changes in the amplitude and frequency of alpha, beta, and theta waves can reflect different states of attention" (Chiang et. al., 2018). Past research that has used EEGs to measure attention utilized the waveforms outputted by the device and then ran statistical analysis to calculate the levels of attention. Researchers from the National Pingtung University of Science and Technology used affordable, compact EEG devices to track students' attentiveness by observing the outputted brain waves that correspond to attention. The researchers used this data to create a classifier with a 76.82% accuracy for determining whether a person is "attentive" or "inattentive." This classifier is meant to be used by teachers in the classroom to tell

if their teaching methods are effective in engaging the students (Liu et. al., 2013). For the purposes of this research, the classifier will be useful for determining how students respond to the different modes of hybrid learning.

Previous studies using EEG devices in classrooms have shown that attention levels vary based on lecture format. PowerPoint presentations and other visual based instruction increased attention levels in students while lecture methods without any supplemental teaching tools decreased their attention levels. Before Covid-19, online lectures were gaining popularity. Many courses at UC Berkeley, including topics in computer science, physics, chemistry, and many others, published recorded lectures to YouTube before online lectures became the only form of lectures (Cheng, 2007). Since then, research has been conducted to see if the format actually allows students to retain information and keep focus. As of June 2021, researchers Gupta and Kumar utilized an EEG device to track the attention level of students while watching online lectures. The goal of this study was to find ways to improve teacher feedback since that ability to receive feedback is diminished by the nature of online learning. The device, similar to that used in other research studies, reads and analyzes the brain activity of the student to measure the attention level. The brain activity measurements can then be conveyed to the teacher who can then use the information to understand whether their teaching method is effective or not (Gupta & Kumar, 2021). Despite this research being conducted with only 10-minute-long videos, it is particularly relevant to my study because it is important to understand that online learning has been tested using neuroimaging techniques and results showed that it can lead to a decrease in students' attention. However, it is also essential to understand that neuroimaging can help improve online learning by giving feedback to teachers.

Ethics

The EEG device that will be used for the purposes of this research is non-invasive and sits directly on the head. This device has been used in research for many years and is typically recommended for people to evaluate brain disorders, sleep disorders, Alzheimer's disease and more. Research conducted by Johns Hopkins University showed that general EEG devices pose little to no risk (Johns Hopkins Medicine). Before choosing subjects for this research, I will ensure that they are not prone to seizures, as EEGs, in rare instances, have been traced to seizures due to flashing lights. Aside from that, EEGs do not interfere with anything inside the brain, such as sending electrical signals that might result in shock.

Methodology

Sample

For this study, I will be randomly selecting 40 undergraduate students from one course at UC Berkeley that is offered in the hybrid learning format. Half of the participants will attend only the in-person lectures and the other half will attend the live online lectures only. Neither ethnicity or gender will be considered when choosing research subjects for this study. As mentioned previously, due to the flashing lights of the EEG lights, students who are prone to seizures will not be included in this study. Lastly, those who have attention deficit disorders, such as ADHD, or students who take attention enhancing drugs also will be excluded from this study because the classifier used in the data analysis may be less successful in correctly classifying these students.

Materials/Technology Use

I will model my research after the neuroimaging methods outlined in the study conducted by the National Pingtung University of Science & Technology in Taiwan. Both groups of students, the in-person group and the online group, will be monitored using the EEG devices during lecture. Exactly 40 sets of EEG devices will be needed for this

research since I will track the brain waves from each student simultaneously during the lectures. All 40 students will be monitored at the same time. I will also need software to read the brain waves extracted from the EEG devices. The study I am replicating created a method to collect the subjects' EEG outputted data that does not require advanced techniques.

The EEG devices that will be used for this study only track brain waves from the frontal lobe in the cerebral cortex, or more specifically the dorsolateral frontal cortex, which is an area that is associated with attention. This area can tell us about attention, focus, and other mental activity (Isaac, 2021). The EEG device used for this non-invasive neuroimaging technique only has sensors in the cerebral cortex to prevent reading brain waves from irrelevant areas of the brain. To analyze the data, I will be using a support vector machine (SVM) classifier. Originally developed by Vladimir Vapnik, the SVM classifier can sort given data into two categories after having gone through a training set using learning algorithms for classification and regression analysis. The researchers from Pingtung University used this classifier model to create their own classifier that predicts a students' attentiveness with an accuracy of 76.82%. Using the data extracted from the EEG devices, I will use the university's SVM classifier to indicate whether students are attentive or inattentive. The classifier can only predict based on two categories, so students will be labeled as either attentive or inattentive.

Design

This research will take place over the course of one semester. Students will be tested during 10 selected lectures within the semester. For the 20 subjects attending lectures in-person, they will put on their EEG device when the lecture starts and will keep it on for the entire duration of the 50-minute lecture. Similarly, the 20 subjects watching lectures online will put on their EEG devices when the lecture starts and keep it on for the 50 minutes. They must put it on and take it off for the duration of the lecture to ensure that the classifier does not misread their attention because they put it on too early or took it off too late. In this study, the independent variable is the format of learning, in-person or online, the subject is using. The dependent variable is the attentiveness or inattentiveness of the subject. How this will be calculated is detailed in the next section. Possible confounding factors that will be considered are emotion/mood and fatigue. In this study, the control group will be the students attending the in-person lectures. The experimental group will be the students watching the lectures online. This way, we can tell from the results if a particular lecture itself is hard to pay attention to or if the online format makes that lecture harder for students to pay attention.

The EEG device is not invasive and relatively simple, so I do not think that it will be unreasonable or bothersome for the students to wear the device for ten sessions. The specific device chosen is "extensively employed for teaching," meaning that it is not the best EEG device on the market, but it is the most ergonomic for the setting (Sensors, 2013). Ideally, I would have the students wear the devices in an entirely different course to test for possible discrepancies between the lectures, however, it is highly unlikely that these 40 students will all be in another course together.

Procedures

First, the students will all be given an EEG device the day before their first lecture. This will be a preparation day for the subjects to become comfortable with the EEG device and to prevent inaccurate results arising from the student's feeling of discomfort. Ten minutes before their first lecture, they will take a survey to check their well-being. The survey will consist of two questions, "how are you feeling today?" and "how many hours of sleep did you get last night?" The first question will be asked on a 5-point Likert scale to avoid ambiguous responses. The responses, ranging from "really bad," "bad," "okay," "good," or "really good," will correspond to numerical values 1-5, respectively. These two questions will be used later to better analyze the data from the EEG devices. The questions will be asked before each of the ten lectures begin.

Next, once the lecture begins, each student will place their EEG device on their head and make sure the device is turned on. Throughout the 50 minutes, the data from the EEG device will be recorded and the classifier will immediately identify if the student was attentive or inattentive during the lecture. After the 50 minutes is over, the student must take off the EEG device. The student will fill out the two-question survey before the lecture begins and repeat the same procedure for the remaining nine lectures. I will keep track of whether the student was attentive or not over the course of ten lectures.

Data Plan

First, I will begin to analyze the survey data to track fatigue and mood. For the "how are you feeling" question, I will analyze each of the participants' scores. On the scale, a response of "really bad" corresponds to 1 and "really good" corresponds to 5. This will be called the emotion score. For any subject with an emotion score less than or equal to 2, I will exclude their EEG data for that lecture. In the research paper "Cognitive approaches to emotions," Oatley and Johnson-Laird found that emotions can affect several cognitive functions, including attention. According to the paper, "happiness tends to broaden it" and "anxiety tends to narrow it" (Oatley & Johnson-Laird, 2014). In addition to the emotion question, if a student received less than five hours of sleep, their data will also be excluded from the data. Research shows that less sleep will result in impaired attention abilities (Chua et. al., 2017). Therefore, in order to exclude inaccurately classified results, I will not consider data that might be affected by the student's emotional state or sleep deprivation.

The results from the EEG devices will be sorted as follows. For each of the 10 lectures, the proportion of attentiveness will be calculated for each of the two groups. After excluding subjects from the previous step, the proportion will be the number of students who were classified as attentive in the group divided by the total number of students in the group. This will be called the group attention score. My hypothesis is that the in-person group will pay more attention in class due to some drawbacks of online learning. If the data shows that the in-person group attention score is higher than the online group attention score, then my hypothesis will be correct. If results find that both groups pay equal or similar levels of attention to the lecture, then the hybrid learning system for this specific course is successful in keeping students engaged. To reiterate, if the independent variables, in-person and online lectures, have a significantly different effect on the dependent variables, the attentiveness of the student, then it can be used to show professors that one mode of learning is not keeping students attentive, and their hybrid learning format may need to be adjusted.

As previously discussed, attention is limited. The more distractions there are, the less focused the student will be. Assuming the data supports my hypothesis, it may be inferred that in-person learning is more effective than online learning in terms of keeping students engaged. Wavering attention due to technology is not a new phenomenon. With the rise of technology, it has become increasingly more difficult to ignore distractions. In order to maintain focus, one must control their attention network by enhancing goal relevant attention. If the data supports my hypothesis, that students paid more attention to the lecture when attending in person, then it will be congruent with this idea that distractions at home cause people to struggle to control their attention network (Issac, 2021). In this case, the lecturer must use more techniques to enhance the attention of students watching lectures online.

Conclusion

There is a lack of research directly comparing the attention of students who attend a lecture in person and different students who watch the same lecture online. Previous research claims that in-person lectures are more effective in keeping the attention of students due to fewer distractions. However, some students have explained that they prefer the format of online lectures. To satisfy both parties, "hybrid learning" is a new mode of learning where students who want to be in-person can be in person, and those who prefer the online format can remain watching lectures online. In

an attempt to see how effective hybrid learning is in keeping both students watching online and attending in-person attentive, I will use a noninvasive neuroimaging technique to track attention levels in students while they are attending lectures in person or watching the same lectures online. Using an EEG device that attaches to the frontal lobe, I will be able to read the brainwaves of each student to gather data. I hypothesized that the in-person group will pay more attention in class due to the certain drawbacks of online learning. In the context of cognitive science, results supporting the hypothesis are congruent with what we know about attention in that it truly is limited and selective. Hybrid learning may be a more flexible mode of learning for both in-person and online students, but the nature of the online lecture offers too many distractions for students to pay equal attention.

It is important to note some additional limitations in this study. The first limitation to this study is that students learn in different ways. Some are visual learners, while others are auditory learners. This study ignores the different techniques of learning, which does play a role in how much a student will pay attention. A second limitation is that not all teachers are familiar with technology. Older professors who might not be as technologically-savvy can have a harder time with the online format and thus cannot engage their students as well through the screen. Given the ongoing pandemic, students should be given an option to watch online, even if that is a less optimal format, or attend in-person in order for them to feel safe on campus. I recommend that professors can use this data in order to test and find techniques that can help them better engage their students online if the attention level is low with the online group. Lastly, attentional bias is not considered in this study. Attentional bias is the idea that emotion can affect attention, as claimed by cognitive psychologist Gordon Bower (Isaac, 2021). Since I am not choosing a specific topic of class to conduct this study on, bias may play a factor in the subjects' attention. For example, if a student is sad and the lecture content is sad, the student is more likely to pay attention to what is said in lecture due to attentional bias. In future studies, it may be important to conduct this study in a course that is not likely to elicit strong emotions. In addition, as explained above, I recommend bootstrapping the data if the sample size is relatively small, like in this study. One major limitation to this study is the size and variation of the subjects. In order to be reasonable with budget and students' time, the study must be limited to 40 students and only one course. In the future, it would be helpful to conduct this same study in other courses.

As the pandemic is still ongoing and new variants are arising, it is important to study how hybrid learning affects students and how professors at UC Berkeley can maximize the effectiveness of their lectures. Professors are encouraged to try new teaching techniques in order to keep students both watching online and attending in-person engaged and equally attentive. Post-pandemic, students can benefit from the continuation of hybrid learning for certain classes. Now that we have almost two years of collective experience with online learning, students have adapted to these new ways to pursue their education and appreciate the flexibility of hybrid learning. Using this research study, professors can better develop or begin to implement hybrid lectures into their courses to meet the needs of their students.

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