Resume:
This article presents a methodology for the collection and study of multimodal data through the integration and use of a brain-computer interface system better known as BCI, which facilitates the reading of physiological activity through electroencephalography techniques. (EEG) to analyze the cognitive processes that occur in subjects who are in a classroom voluntarily willing to learn. The NeuroSky brand BCI device is considered a low-cost device, which was used in conjunction with the free neuroexperimenter software, where when used together, multimodal data collection is achieved in a traditional classroom; The products obtained served as a basis for analyzing the learning processes, to understand what happens from a perspective of cognitive neurosciences. The products of this methodology can be used as a reference to build reports in order to provide feedback to teachers, where the physiological data of the levels of attention in students open the opportunity to interpret the impacts of teaching activities.

Keywords:
teacher evaluation, classroom, physiology, new technologies, science and technology.

Abstract:
In this paper, we aim to offer a methodology for the collection and study of multimodal data through the integration and use of a brain-computer interface system better known as BCI, which facilitate the reading of physiological activity through electroencephalography (EEG) techniques to achieve. analyzing cognitive processes that occur in subjects who are within a classroom voluntarily willing to learn. The BCI device of the NeuroSky brand, which is considered a low cost device, was used in conjunction with the free use neuroexperimenter software, where, being used together, it is possible to collect multimodal data in a traditional classroom; the obtained products served as a basis for conducting analysis of learning processes, to understand what happens from a perspective of cognitive neuroscience. The products of this methodology can be used as a reference for building reports to provide teachers feedback, where physiological data on the levels of attention in students open the opportunity to interpret the impacts of teaching activities. The relevance of this paper lies in the opportunity found to use BCI technologies so as to carry out studies within a classroom in an objective manner without using instruments such as a questionnaire. to understand what happens from a perspective of cognitive neuroscience. The products of this methodology can be used as a reference for building reports to provide teachers feedback, where physiological data on the levels of attention in students open the opportunity to interpret the impacts of teaching activities. The relevance of this paper lies in the opportunity found to use BCI technologies so as to carry out studies within a classroom in an objective manner without using instruments such as a questionnaire. to understand what happens from a perspective of cognitive neuroscience. The products of this methodology can be used as a reference for building reports to provide teachers feedback, where physiological data on the levels of attention in students open the opportunity to interpret the impacts of teaching activities. The relevance of this paper lies in the opportunity found to use BCI technologies so as to carry out studies within a classroom in an objective manner without using instruments such as a questionnaire. where physiological data on the levels of attention in students open the opportunity to interpret the impacts of teaching activities. The relevance of this paper lies in the opportunity found to use BCI technologies so as to carry out studies within a classroom in an objective manner without using instruments such as a questionnaire. where physiological data on the levels of attention in students open the opportunity to interpret the impacts of teaching activities. The relevance of this paper lies in the opportunity found to use BCI technologies so as to carry out studies within a classroom in an objective manner without using instruments such as a questionnaire.

Keywords:
teacher assessment, classroom, physiology, new technologies, science and technology.

Reading cognitive activity through the use of EEG instruments is an increasingly common practice that is performed using BCI technology. This technology uses EEG devices that are expensive and not easy to operate. The recent launch of low-cost wireless EEG devices opens up the possibility for the research community around the world (Das, Chatterjee, Sinharay, & Sinha, 2014).

Neurosciences and information technologies today have evolved to such a degree that they can support each other to identify the physiological signals that are generated by emotions and motivation triggers by means of electroencephalogram (EEG).

EEG techniques consist of obtaining electrical signals from brain activity and are divided into two types: the first is invasive, where electrodes are implanted inside the patient's skull, which despite the related natural complications, this has to favor the fact that the signal can be focused, distinguishing a specific area of the brain; The second technique is non-invasive, it consists of placing sensors on the scalp, through pairs of electrodes that are used to read the electrical signals of the electrical activity of the brain. Both types of techniques consider the principles of small voltage differences between electrodes and these usually register values of between 30 and 100 μV, so they normally must be amplified,Torres, Sánchez and Baus, 2014).

BCI devices and their applications

Since the human brain by its nature is divided into cerebral hemispheres and these in turn are divided into lobes, the BCI device that is considered in this functional study in reading the frontal lobe, where it is this lobe where all functions are performed as a series of processes, whose main objective is to facilitate adaptation to new situations; it operates by modulating or controlling basic cognitive abilities. Bello (2016) declares that these skills are super-learned processes through practice or repetition and includes motor and cognitive skills such as reading, memory and language.

Today, various technologies have been identified that allow the reading of brain activity through EEG techniques, one of them is identified in the study carried out by Uşak University in which they monitored the attention levels of students when using visual materials. in courses using electroencephalography. In this research they evaluated the use of resources such as PowerPoint, the internet, digital maps, graphics, comparing their use in LMS platforms and in master classes. One of his main research findings was that the flow of stimuli is interrupted more frequently in face-to-face classes, mainly when a classmate enters late or due to conversations from others outside the class,Sezer, İnel, Seçkin and Uluçınar, 2015).

Another research case is the development of an application called EngageMeter; which is a system that allows obtaining precise information in real time about the level of attention that students have in a course, through the use of BCI, where the data obtained reflect the reactions of the audience in class when witnessing presentations, in this way In this way, they obtain guidelines on how to present their slides and insert additional elements (Hassib et al., 2017).

Xu, Zhou, Wang and Peng (2018) analyzed 22 works where the use of BCI devices was carried out, identifying that in 82% of the works the NeuroSky device was used, additionally these same authors highlight that there is a shortage of studies on the naturalistic classrooms, where the obtaining of data from the brain waves of the students is reflected within their classrooms, for which there is a need to carry out studies in this area.

The Neurosky device

New technologies such as BCI allow psychology and even neuroscience applied to education to establish actions to close some gaps in the field of education, where learning analytics provide the potential to support a deeper understanding of the student behavior as they learn in real educational settings (Lodge & Corrin (2017) as cited in Corona, Altamirano, López & González, 2019).

NeuroSky brand Mindwave EEG devices are low cost and easy to manipulate, these devices have a single reading channel and sampling frequency. The lowest sample rate they operate with is either 128 Hz or 256 Hz, but this does not pose any serious problems as the brain signal is mostly limited to 30Hz as far as BCI applications are concerned (Das et al., 2014).

Xu et al. (2018) present that the NeuroSky brand device has been used in research works where the study of attention levels is involved in activities such as: reading processes, analysis of presentation patterns of materials of learning, gamification and behavior in digital educational environments such as e-learning.

The BCI Mindwave device consists of three parts; Its first and main part is a hardware with an EEG sensor that reads the activity exclusively in the frontal lobe, where the brain activity data is read by a single channel EEG dry sensor, which allows reading physiological information and is located in the frontal lobe. The second part is a bluetooth module that works as data output technology by allowing the link with a computer and the third part is a software library called Think Gear, which works as a link between the device for data collection and a computer equipment; this library has its own development interface, which guarantees flexibility.

A study by Rogers et al. (2016) reported that EEG data derived from a ThinkGear system contained within a Neurosky brand device is comparable to EEG recorded from a conventional laboratory system and is sensitive to standard variations of resting states of mental processing. and active.

A tool that can operate the BCI Mindwave is the free software Neuroexperimenter developed by Mellender (2016) which addresses this gap and uses the ThinkGear library to store the data of alpha, beta, gamma, delta, theta, in its high and low levels, in addition to the levels of attention and meditation in CSV and R formats, data in each reading session.

Since the Neurosky brand BCI has a software development library, it has been identified that Mellender's neuroexperimenter software (2016) is a versatile complement for use in traditional classroom contexts, in this regard Das et al. (2014) state that the neuroexperimenter software works as a support for the EEG data acquisition device, in other words, this software works as a support instrument for reading brain signals.

Xu et al. (2018) indicate that there is evidence of the use of the BCI NeuroSky device in research on levels of attention in reading processes, presentation guidelines for learning materials, gamification, behavior in digital educational environments such as e- learning.

Neurosciences in educational contexts

Immordino-Yang and Fischer (2009) state that the new technological resources that have been developed for neuroscience research bring new information and new challenges for interpretation; In order to make sense of what this author has stated, it is essential that teachers understand the logic and limitations proposed by the new developments for neuroscience research.

Considering the use of neuroscience techniques in educational contexts, allow understanding the learning processes; Rodríguez (2008) highlights when teaching is completed by producing the meaning of the material that the teacher presents to the student, EEG techniques allow research to be approached from a constructive integration, by combining an interpretation of thought, feeling and action, being the result of this a new perception of educational research.

Goswami (2006) states that currently in society there is a goodwill of teachers and educators towards the discovery and application of neurosciences, since they are interested in the subject, they feel that it has the potential to make important discoveries about human learning and they are eager to learn about these discoveries. In the same way , Valderrama and Ulloa (2012) state that there is interest in the detection of human mental states through the analysis of physiological parameters of the brain.

Brain activity provides neurophysiological data, these serve as a trace for the analysis of learning. There are few contributions where the traces of physiological activity are considered for

research in learning; During their research exercise, they monitored the brain activity of subjects who played serious games in front of a computer. With this research, Ninaus was able to identify the brain states that are directly associated with learning certain activities, to subsequently improve learning in Yeah. In her exercise, she used neuroscience techniques in order to transfer neurophysiological data to numerical data to later carry out a statistical analysis under a qualitative approach (Ninaus et al., 2014).

This type of physiological measurements carried out within a classroom are of significant value , state McCain, Mustard and McCuaig (2012)., since when you are in a degree of emotion, the human body releases hormones that prepare the disposition for action, therefore to be with a significant degree of attention in a traditional face-to-face class, you need to be excited enough to be alert and engaged, formulating an essential state for learning; Therefore, a research opportunity opens up with low-cost sensors such as those of the Neurosky brand, since in the face of a stressful situation for a subject, the adrenal glands, which form the nervous system and parts of the prefrontal cortex of the brain, are the that will determine the form of behavior to respond to external stimuli that formulate the stressful situation,

When we talk about learning, the first thing that comes to mind is the scenario of a classroom where a teacher and his students meet; To carry out their learning processes, the student uses her brain, which is the place where emotions are manifested, so emotions and learning are related. From a biological perspective, learning can be defined as the process that allows acquiring knowledge about the world, which depends on memory, since it is the process of retaining and reconstructing this knowledge over time (Aguilar, 2017).

In support of the above, Goswami (2006) states that good teaching practice can be undermined by brain factors such as learning anxiety, attention deficits and poor recognition of social cues. All these factors disturb the learning capacity of an individual and also have an effect on other students in the same class, which is why they must be studied. In addition , Xu et al. (2018) suggest that through EEG techniques, it is possible for teachers to instantly identify the mental levels of students, and thus take their practice to make them attentive and meditative in order to improve the effects of learning. .

Attention from a cognitive perspective and following the information processing theory model, can be analyzed from two main categories; first as an ability to attend a given moment for as much information as possible. In this case, attention is considered as an action that involves a series of abilities to discriminate between relevant and irrelevant stimuli, selecting the correct stimulus and staying focused for a long period of time; and second as the ability to switch from one source of information to another, that is, having the ability to change the stimulus when completing a task, inhibiting other stimuli involved (Cubero, 2006; Barrón, s/f, as cited inGavotto, 2015).

Gavotto (2015) , like Temoche (2014) , suggest that studying attention during the teaching-learning process implies recognizing that education is a complex process, this means that it is not possible to predict the behavior of people who are exposed to it. this type of processes, nor their results, due to the fact that various situations and circumstances arise that put concomitant variables into play.

Valderrama and Ulloa (2012)suggest that emotions in their contexts according to different dimensions represent an affective treatment, the validity of this lies in the relationship between the physiological characteristic and the arousal due to the activation of the automatic nervous system when the emotion is generated, while at the same time measuring the levels of attention and meditation through EEG techniques, subjective interpretations of perceptions are avoided and thus support the interpretations through quantitative data of the physiological availability of each student to achieve learning; When interpreting these results, the data obtained should serve as a frame of reference so that a teacher can have a reference parameter to know the efficiency and effectiveness of her activities in front of the group.

As it has been framed in the previous paragraphs, there are gaps in the use of BCI devices in face-to-face educational contexts, for this reason this article focuses on the individual measurement of mental states of attention and meditation in students in a classroom, in order to Build data sets that allow understanding how learning conditions affect a group of students in a classroom by using the BCI instruments and the neuroexperimenter software.

METHODOLOGY

For the development of this methodology, the use of mixed methods was considered under the data triangulation method, where according to Tashakkori and Teddlie (2010) as cited in Hamui-Sutton (2013), the mixed methodology has in its structural base the possibility of looking for the practical applications of the findings in the results. On the other hand, these same authors justify that when quantitative and qualitative data are obtained in a systemic way, there is the possibility of reconstructing the moments, as long as the data is collected under the consideration of a common timeline. Based on the above, it is possible to use a BCI device for the acquisition of alpha, beta, gamma, delta, theta physiological signals, as well as attention and meditation signals under the time line proposed by the neuroexperimenter software along with observation. naturalist, always considering the same software reference base so that in a second stage,

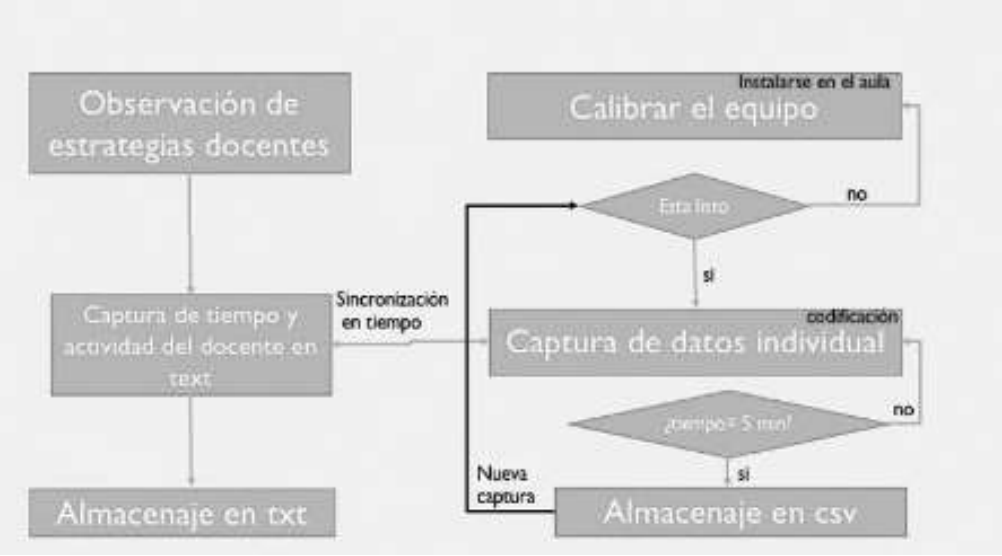
An operational limitation that considers the proposed methodology is the moment of reading a session as a unique and unrepeatable moment, since when students enter the classroom they do so from an external context, which can influence the physiological or emotional state. of each student; on the other hand, the sequences of content presented by the teacher change in each class, this leads to taking as a restriction of this methodology and considering reading times of 5 minutes for each subject in order to record brain activity at a average of 8 students per session.

One restriction that was placed on the subjects who were considered participants was to avoid wearing glasses or earrings, since the Neurosky brand EEG sensor does not make a stable reading when the subject wears any of these objects. All the data obtained through the use of the neuroexperimenter tool were organized in CSV format, which allows data portability for its representation, as well as to be loaded into various data tools such as R Estudio, Python or Excel to carry out analytical processes. .

The study presented in this article was carried out within the facilities of the Academic Division of Informatics and Systems of the Universidad Juárez Autónoma de Tabasco, which is located in the southeast of Mexico. The data obtained were carried out within the spaces of a classroom, where students from two groups of the degree in computer systems were included at different times. The results addressed specific situations of the aforementioned academic division, where all agreed to participate voluntarily in the research exercise, giving them anonymity at all times.

Figure 1 shows the steps taken for the data collection system; In order to maintain naturalism in the group, a portable computer was installed inside the classroom, without visually and contextually contaminating it, which is why it is located at the back of the room. After that, the teacher is allowed to start his class and the recording of data on the brain activity of each student begins, thus applying what is stated in Figure 1 .. As shown, the taking of note of the activity carried out by the teacher allowed to build the qualitative data while the BCI device built the quantitative data, both data were integrated under the same time line to thus create the triangulation of the levels of attention achieved. in students with their teaching practice.

Figure 1. Systematization model for data acquisition of physiological signals



The BCI device together with the neuroexperimenter software are instruments that allow the acquisition of data, specifically EEG instruments designed to read brain activity (Das et al., 2014). These instruments allow the creation of data models in CSV format, in which data analytics were subsequently performed.

Thanks to this technique, readings were carried out in two classrooms, where in each classroom there were 4 male and 4 female students as study subjects, which produced more than 56,000 data, which were structured into alpha, beta1, beta2, gamma1 signals. , gamma2, theta, attention and meditation, these were acquired in their classroom while the subjects were active as students in their respective class sessions.

The data reported in this article has a nature in the students involved in the study, product of the stages of data collection and processing in real time, to build the sets of values of the alpha, beta, gamma, delta, theta signals, as well as such as the attention and meditation data obtained through the dry EEG sensor, through the acquired data it was possible to build a data set that describes the realities represented in numerical data of the events manifested in the students during the learning process. , through the student's behavior in their classroom context. Being data obtained from the physical context through mediations of technological resources Amo and Santiago (2017)state that, by their very nature, they can be called as multimodal data.

RESULTS

By having the representations of the data coming from the physiological activity and the teacher's activities, in a systematized way it is possible to benefit teachers with feedback, since the time series with the data represented are created from the effects on their students. This result integrates the observations and the physiological signals under the same time base. For this research, the measurement of the attention and meditation levels of the students in an educational context on a voluntary basis, are the naturalistic basis; according to Glejzer (2017) attention is basic to lead to mental or cognitive states conducive to learning processes

In the study, data sets of attention and meditation signals were generated for each student to carry out the study, which they represented in ranges from 0 to 100, under this structure in a general way the levels of attention and meditation were reached. Additionally, the physiological activities produced by alpha, beta, theta, delta and gamma were read, which reflect the intensity of cognitive processes during the class session.

The manufacturer of the NeuroSky device has established attention level metrics under the eSense metric scheme, where it defines that the attention values are represented on a scale from 0 to 100, where the ranges from 40 to 60 indicate that the subject is in a natural state of cognition, while ranges from 60 to 80 reveal a high level of attention and ranges from 80 to 100 are very high levels of attention.

For this study of two class groups, more than 56,000 data items were combined, of which 4,340 represent data on attention and meditation resulting from physiological activity in 16 students during a 5-minute reading for each one. Each individual data represents a case and integrates information from the five physiological signals, as well as attention and meditation measurements. In the interpretation of the data shown in Table 1 , it is identified that in most cases the men manifested a persistence of low levels of attention during their participation in the class, which does not mean that they were continuously neglecting the course. .

Table 1. Results of the levels of attention and meditation of groups 1 and 2.

Group 1	**student**				**student**				**Average**
	one	2	3	4	one	2	3	4	
attention	48.36	53.49	28.33	64.05	25.87	20.87	48.4	35.56	40.61625
meditation	45.49	53.47	53.88	51.9	63.29	65.21	49.06	29.39	51.46125
Group 2	**student**				**student**				**Average**
	one	2	3	4	one	2	3	4	
attention	48.34	37.78	28.33	64.14	39.24	45.4	20.87	35.66	39.97
meditation	45.61	53.47	53.88	51.89	45.88	49.05	65.22	22.99	48.49875

The readings of the levels of attention and meditation are highly valued when analyzed using the eSense metric, this is due to the fact that the manufacturer's specifications of the BCI device define their own ranges to apply metrics of levels of attention and meditation. This manufacturer declares that measurements between 40 and 60 correspond to a medium range of activity considered as a neutral level. With the eSense parameters, then, it can be interpreted that the data that is between the range of 40 and 60 on the scale from zero to 100 of attention and meditation are normal ranges of activity; therefore the readings of the students in group one are predominantly in a normal range, however student 3 and students 1, 2 and 4 present values below the normal range,

For group two, however, student three and student three present states of distraction or agitation in a similar way to that of group 1, thus giving these behaviors out of the ordinary with the rest of the groups.

Therefore, under the average values approach, we can say that in group one there were more students in a state of distraction and lethargy while in group two only two students, a woman and a man, were the ones who had this behavior on average. of total distraction. Since the data is obtained from the physiological activity of the students, this gives a higher level of certainty, since during natural observation this type of behavior was not observed in the identified students, therefore, the physiological data provide support. of the state that prevail in the classroom.

In the total average values of each group it can be seen that the values are at a level higher than 40, however, it is necessary to clarify that for the meditation levels it is not necessary to have a direct interpretation as a lethargy as it is, since the levels of meditation are necessary to make calls to the memory processes for example.

CONCLUSIONS

By introducing electroencephalography techniques to measure the levels of attention and meditation through the physiological activity of each student, it allows opening a new alternative to

know the true state of a student in a traditional class, since these measurements in combination with natural observation allow to build interpretations with a high level of fidelity what really happens in a class. These readings are a contribution by providing a new reference to know the stimulus that teaching practice represents to know how much their availability to evoke in learning processes within the classroom causes in the state of a student in a face-to-face class session.

On the other hand, given the nature of the data used in this study, it can be said that there is greater certainty and the bias of the subjectivity of the written or verbal response by the student is no longer a parameter of contamination or tendency to measure, because the physiological state with the EEG sensor measures the mental state under which the brain is operating in a class, this being a relevant process by opening a new area of opportunity for educational research.

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