Monterrey, Nuevo León, 08 de Noviembre de 2019

A quien corresponda,

El Comité Organizador del Taller en Innovación Educativa en Ingeniería y Ciencias hace constar que los trabajos:

Título 1: **Physiological and Behavioral Data Capture of Students for the Automatic Recognition of Learning-Centered Emotions**
Autores: **Yesenia Nohemí González Meneses, Josefina Guerrero-García, Carlos Alberto Reyes García, Iván Olmos Pineda, Juan Manuel González-Calleros**

Título 2: **A Web-plugin to Reduce Inattention of Students in Web Search Tasks**
Autores: **Alfredo García, Juan Manuel González-Calleros, Josefina Guerrero García, Amparo Palomino**

han sido aceptados para ser publicados en el International Journal on Interactive Design and Manufacturing (IJIDeM), Q2 indezado en Scopus, con ISSN: 1955-2505.

Sirva la presente para los fines que el interesado convenga.

Atentamente,

Dr. Rubén Morales Menéndez
Presidente del Comité Organizador
https://virtualconcept.estia.fr/r10/#home

Tecnológico de Monterrey

Virtual Concept International Workshop

Monterrey, Nuevo León, a 08 de Noviembre de 2019

Estimado Dr. Juan Manuel González Caballero,

Por este medio le comunicamos que sus ponencias tituladas **"Physiological and Behavioral Data Capture of Students for the Automatic Recognition of Learning-Centered Emotions"** y **"A Web-plugin to Reduce Inattention of Students in Web Search Tasks"** han sido aprobadas para ser presentadas en el **Taller en Investigación Educativa en Ingeniería y Ciencias (Virtual Concept Conference)** el cual se llevará a cabo el 17 de Diciembre de 2019 en el marco del **6° Congreso Internacional de Innovación Educativa**, mismo que tendrá lugar en Monterrey, Nuevo León, México del 16 al 18 de Diciembre de 2019. Ambos trabajos serán publicados en las memorias del evento con ISBN número 978-2-9548927-7-1

Agradecemos de antemano su participación en el congreso y le sugerimos comenzar a realizar los trámites requeridos para que nos pueda acompañar el día del evento.

Dr. Rubén Morales Menéndez

Chair del Taller en Investigación Educativa en Ingeniería y Ciencias

A Web-plugin to Reduce Inattention of Students in Web Search Tasks

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Abstract

The attention in people is associated with efficiency in their intellectual activities, in their level of understanding and in the development of their information seeking ability. The searching on the web in the classroom factors that may affect or benefit students' outcomes are numerous. In this paper, a small-scale observational study using a web plugin analysis was conducted with two groups, control and experimental, of college students who carried out web search tasks in small groups of four students. Qualitative and quantitative analysis were performed on their results. Preliminary results showed that: (1) students with the plugin finish earlier their work; (2) the quality of the work in the experimental group was as good as the control group; and (3) in the control group it is normal that some teams do not finished correctly the activity on the experiment while this was not the case in any team in the experimental group. On the qualitative the following observations where made: (1) searcher's attitude changed positively with the web plugin, (2) students satisfaction increased. Last, the experiment collects data to document searcher behaviors, such as EEG, speaking, and facial expressions.

Keywords

Attention Level, Brain Waves, Teenager Attention and System Acquisition, Educational Innovation, Higher Education.

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A Web-plugin to Reduce the Inattention of Students during Web Search Activities

Abstract

The attention span of people is associated with efficiency in their intellectual activities, in their level of understanding, and the development of their information-seeking ability. The factors that may affect or benefit students' outcomes when they are in class and searching on the web are numerous. In this paper, a small-scale observational study using a web plugin analysis was conducted with two groups of college students, control and experimental, who carried out web search tasks in small groups of four students each. Qualitative and quantitative analyses were performed on their results. The preliminary results showed that (1) students with the plugin finished their work sooner; (2) the quality of the work in the experimental group was as good as that of the control group, and (3) in the control group, it was normal that some teams did not finish the activity of the experiment correctly, while this was not the case for any team in the experimental group. In the qualitative analysis, the following observations where made: (1) the searcher's attitude changed positively with the web plugin, and (2) the students' satisfaction increased. Last, the experiment collected EEG and verbal data to document searcher behaviors.

Keywords

Attention Level, Brain Waves, Adolescent Attention and System Acquisition, Educational Innovation, Higher Education.

1. Introduction

Attention Deficit and Hyperactivity disorder [ADHD] is a cognitive disease, and it is one of the most common childhood disorders. However, it can prevail through adolescence and adulthood. Statistically speaking, it affects 4.1% of U.S. adults. Furthermore, according to the Centers for Disease Control and Prevention (CDC), 11% of children between ages 4 and 17 years in the U.S. get diagnosed with this disorder (6.4 million), and the number is increasing rapidly. According to the National Institute of mental health, there are many symptoms related to ADHD that include inattention, so the person cannot concentrate on a task for a long period of time. Usually, the person is disorganized. However, this does not have to do with a lack of comprehension.

There are several ways to face this disorder; the first one is the medication. Also, this can be combined with behavioral therapy, in which the person monitors his own behavior. Other solutions recommended for people with this decease are keeping routines, making lists, and using calendars and notes. Other sources, like Impact ADHD, report that it is actually possible for the people with ADHD to learn how to avoid distractions. Techniques such as putting away the phone and any device that generates notifications are recommended to the teachers to prevent the wrong use of devices. However, from our experience, students disagree with the use of such measures so, we wonder how to empower the student to make correct use of electronic devices (self-regulation) while at the same time preserving the principal goal of the school, which is to learn? What is the solution? The other research questions that we discuss in this paper using the web-based search task as a reference activity are: How to measure if such a solution contributes to focusing the students on their activities whether they have ADHD or not? How to identify the effect on students´ emotions before and after using the solution? Is the effect positive, negative, or neutral?

First, in our current context with a flipped classroom and online education, the use of a web browser and mobile phones is a “must” during the courses; furthermore, to do the class activities, the students must undertake web search and interactive activities. The problem is that some activities are taking longer than expected to be completed correctly. From our study, we note that one of the reasons is the lack of students’ focused attention as they perform several parallel activities while searching for information on the web browser. They become distracted by social networking, WhatsApp being the most common, and others such as YouTube videos. Indeed, social networks such as Facebook have been reported to affect students´ performance in [39]. We need to find solutions that meet the students’ needs and keep them satisfied that they have control but also prevent the inappropriate use of software while using a device during a class activity.

Consequently, we would like to measure students´ satisfaction in terms of emotions. The effects of emotions on students and the interpretation of the messages they receive have been reported [33]. Feelings are the result of emotions and affect moods that occur in a person. Emotions are psycho-physiological expressions; biological and mental states suffer adaptations of the individual to stimuli caused by the environment, and it has been shown that emotions affect most human activities, among which are creativity, decision making, and communication [37]. The role of automatic emotion recognition is growing since much time ago. This is because the importance of the reaction to the affective states of the user in the human-computer interaction has been accepted. As computers become more and more specialist, whether professionally or socially, it induce the interaction naturally, that is, similarly to human interactions. "The most important feature of human interaction that guarantees that the process is done naturally is the process by which we can infer the emotional state of others. This allows adjust the patterns of behavior and responses and optimizing the interactive human-computer processes" [54]. One mechanism to collect data related to emotions is through the use of Electroencephalography (EEG) monitoring, which can be used as well to monitor attention span.

In this paper, we present a page blocker system for web-based search tasks. Although several page blocker systems are available on the market, this was designed from a deep study of students' needs in connected classrooms. The use of computers and mobile phones is mandatory in computer science courses, but the "correct" use of technology is somehow ambiguous and hard to determine. To keep students focused, we proposed a solution that not only uses a page blocker mechanism but also employs gamification strategies, bringing flexibility to the system. Contrary to just simply blocking access, the students were allowed to access any website, even those blocked, with soft consequences, such as losing some decimals to the activity score. In this scenario, the students started to become aware of the benefits of being focused on their activities. Lastly, they were in charge of selecting and adding the websites that they believed should not be used during their activity. By using this approach, the flexibility to use web browsers became simplified; the need to have a huge list of forbidden web sites to be automatically blocked was avoided.

In this research, we report on the quantitative and qualitative methods in a small-scale, mixed, observational study with two groups of undergraduate students in a private and public university in the southeast of Mexico. The control group performed the standard activity while the experimental group did the activity with the web plugin.

The remaining of the paper is organized as follows: Section 2 presents the literature review; Section 3 presents the methodology, including the implementation and data collection procedures; Section 4 synthesizes the preliminary results obtained and the discussion with regard to the literature reviewed. Finally, the conclusions and the future work are presented.

2. State of the art

The processing of web information can be described in 5 steps, hand in hand with the recommendations for multimedia learning that have been shown to be effective. This is the reference model [48] for the cognitive perspective to deal with a search task on a web-based solution. The latest research on the mental process shows that people receive 40 million sensory inputs every second. When we perceive a sensory stimulus, we perceive that something exists; we do not necessarily have to remember or do something with the information. A large amount of mental resources is consumed in thinking, remembering, processing, representing, and encoding information. This is called the *effect of recent* [52]. If we have a limited capacity, we need to identify the limit of each channel. A student can effectively perform his tasks as long as he is not distracted and/or his information processing is not interrupted [48].The more we can focus on what we want to learn, the better is our ability to remember; this is directly linked to the ability to discern non-relevant things. Consequently, our goal in this project is to prevent students' distractions where they remember information from different places and read letters or numbers in one section and write them down in another. Not preventing distractions will not only produce unsatisfactory results but, above all, it will frustrate the students and prevent them from getting good grades [48]. So, we must facilitate the searching activity by having the students focus only on it and nothing else.

2.1 The Relationship between States of Attention and Level of Attention

Various applications in areas such as psychology, education, business, and health require a system that accurately identifies the level of attention in people, provides immediate feedback about what is happening, and makes a reliable final diagnosis for decision making. It is also desirable to obtain feedback that encourages the user to raise the level of attention at the same time as executing a specific task [53].
Formally speaking, to identify attention correctly, the study of physiological signals such as brain waves, heart rate, body temperature, and others [51] has revealed great advances in recent times, obtaining significant results in applications from different fields of study such as medicine, robotics, and psychology [34]. The history of the electroencephalography was began when Hans Berger discovered it in 1924 [37], and it consists of getting an electrical signal that depicts the functioning of the brain. The speeds of data acquisition and processing of devices such as those of MINDWAVE, EMOTIV EPOC, and MUSE [38] have delays and cannot obtain readings of the acquired variables in a time that approximates real-time. Other disadvantages presented by this type of device are its low usability [35] and versatility in practice since the user requires a long time for the devices to recognize the physiological signals that are desired.
There are two groups of devices:

1. In the invasive devices, the electrodes are implanted inside the patient's skull, where, the behavior natural is lost, the signal can be leaded and distinguish a specific area of the brain.
2. In the non-invasive devices, the electrical potentials are recorded from the scalp through pairs of conductive electrodes that are used to read the electrical signals. Small differences in voltage between electrodes usually register values between 30 and 100 μV, so they should normally be amplified. Electrical activity occurs when neurons communicate [38].

Some devices have a graphic interface designed by the manufacturer, and the feedback [55] is based solely on the indication of the level of attention graphically. The performance of these devices is limited to the software and hardware established by the manufacturer for a specific task, adding to the lack of accuracy in reading the signals [43] because the devices do not have a robust system for data acquisition and processing. Also, the manufacture is oriented to simple tasks or didactic games. Another cause of the low performance of these devices is that they are invasive or intrusive; Tiaras, helmets, and blood samples are used to obtain the signals of the user's physiological variables; any error in the calibration could generate an error in the final diagnosis.

To know the level of attention in people are necessary some tools or devices to measure this variable. Currently, there is a variety of commercial devices that provide the level of concentration, meditation, relaxation, and user attention quantitatively [52], but in some cases, this are suited as an invasive way, it affects the response of the user and, consequently, the final diagnosis. These devices usually use a physiological variable to infer the levels of attention in people and are of the single-user type [48] and of an accessible cost. The performance of these devices present restrictions by part of the manufacturer on the software and hardware used.

Biofeedback systems keep a specific mental or physical state in a user through a closed loop of bio-feedback. These systems detect the data about of the physiological state of a person using an specific hardware , integrate this state into a computer-based interactive system, and present the comments so that the user can adjust their status [36], [45], [32].

The variety of strategies applied in the field of research to quantify the level of attention of people show an analysis that is presented in this work. In the literature is described an overview of the variables used to relate the level of attention in people, we have found that the brain waves are the physiological variables most used due to the cognitive relationship that exists among the thinking and brain activity. Therefore, are related directly [50], [49], [42].

The graph in Fig. 1 shows the relevance that each one of the physiological variables has on the level of attention of people. This analysis is obtained from the state-of-the-art of the reviewed research literature.

The device chosen to realize the lecture of the signals depends on the physiological variable used. The devices most used in the literature are the electroencephalogram, WEB cam, motion sensors, gyroscopes, electrodes, mouse, electrocardiogram, electrochemical sensors, keyboard, transducers, cameras, and optical sensors [1], [2], [3], [37].

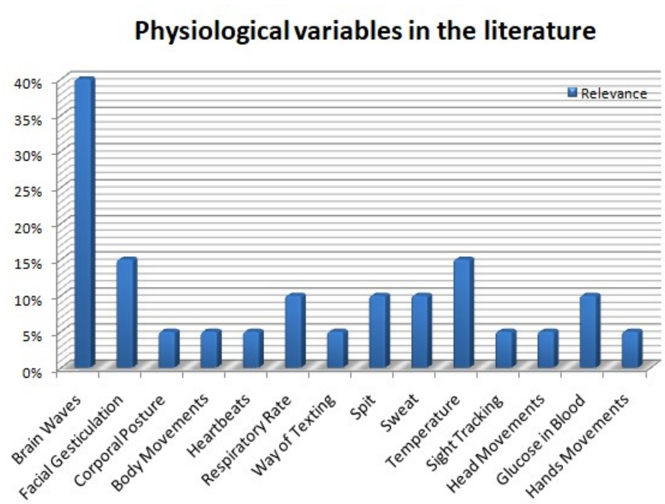

Fig. 1 Methodological Stages.

Table 1 compares the physiological variables, applied techniques, and impact on the levels of attention, as obtained from various sources and scientific articles.

Table 1. Comparison of physiological variables, techniques, and the relation to the levels of attention.

Database	Facial expression	Number of Subjects
Facial Gesticulation	Digital image processing	The automated recognition of emotions can be directly correlated with the levels of attention of a teenager.
Binaural waves (auditory waves)	Modification of the frequency range of the incident waves	Binaural waves have a positive impact on mental states, such as active concentration and creative visualization.
Brain waves (Alfa, Beta, Delta, Theta y Gamma)	Wavelet Transform	Use of the MindWave headband for reading brain signals, which are classified in levels of attention
Brain waves produced by facial gestures	Suites of EmotivEpoc: *Affective, *Expressive, *Cognitive	Use of the EmotivEpoc headband for the reading of brain signals, which are classified into levels of attention.
Brain waves (Alfa, Beta, Delta, Theta y Gamma)	Classification of brain waves in emotions through their frequency variations	The automated recognition of emotions can be directly correlated with the levels of attention of a teenager
Brain waves (Alfa, Beta, Delta, Theta y Gamma)	Bayesian classification and Hill Climbing search algorithm	The automated recognition of emotions can be directly correlated with the levels of attention of a teenager.
Brain waves (Alfa, Beta, Delta, Theta y Gamma)	Digital image processing Affective computing	Automatic feedback can improve levels of adolescent care.
Facial gesturing Body movements	Digital image processing Mouse movement	Application of tasks that require cognitive processes such as attention, memory, and reasoning.
Brain waves Heart waves	Characterization of signal changes Classification of brain and heart waves in emotions through their frequency variations	The automated recognition of emotions can be directly correlated with the levels of attention of a teenager.
Text	E-learning (Identification of emotions through the way of writing a text)	The automated recognition of emotions can be directly correlated with the levels of attention of a teenager.

When the level of attention of the user is known, it is necessary to perform some action that provides some feedback to the user to stimulate their concentration in the activity or task that is being carried out.

In the literature, we found that studies related to the classroom showed that environmental factors, such as cognitive assistance technology (CAT), can help people with cognitive disabilities [44].

One example of the feedback system is the battery of the attention training system. This electronically generated response cost system is placed on a student's desk and managed with a remote control that is operated by the teacher. It is designed to send comments in order to increase the levels of attention related to tasks. This system was more effective than a pre-existing classroom management program that used chip reinforcement [40]. Another example is Watch minder, a vibrating wristwatch. This self-monitoring device aims to increase the task behavior of elementary school children. The results of this study proved effective for two of each three participants. The graph in Figure 2 shows the most used feedback systems to stimulate the state of attention of people in general. In this comparative analysis, it is observed that visual learning environments are the most common tool in the area of cognitive sciences [40], [4].

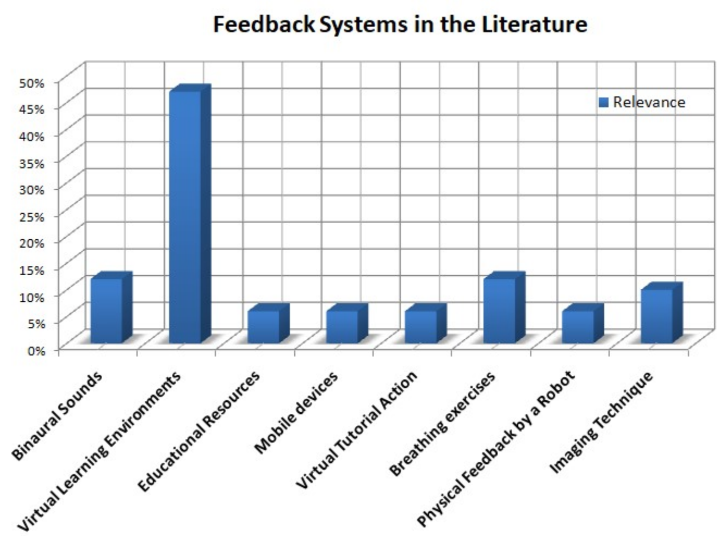

Fig. 2 Relevance of the feedback systems related to the level of attention in the literature.

Figure 3 shows the relationship between the devices used to obtain the data and the physiological variable sensed. The techniques applied to obtain the data of the physiological variables also play a fundamental role since the effectiveness of the final diagnosis depends on them. Table 2 describes a comparison of various data acquisition techniques and their components as a physiological variable, device and software employees, sampling time, effectiveness, and relationship with levels of attention. Based on this review, a selection of the appropriate combination of hardware and software was made for the experiments, namely, measuring brain waves with a headset and recording data with a computer-based desktop solution.

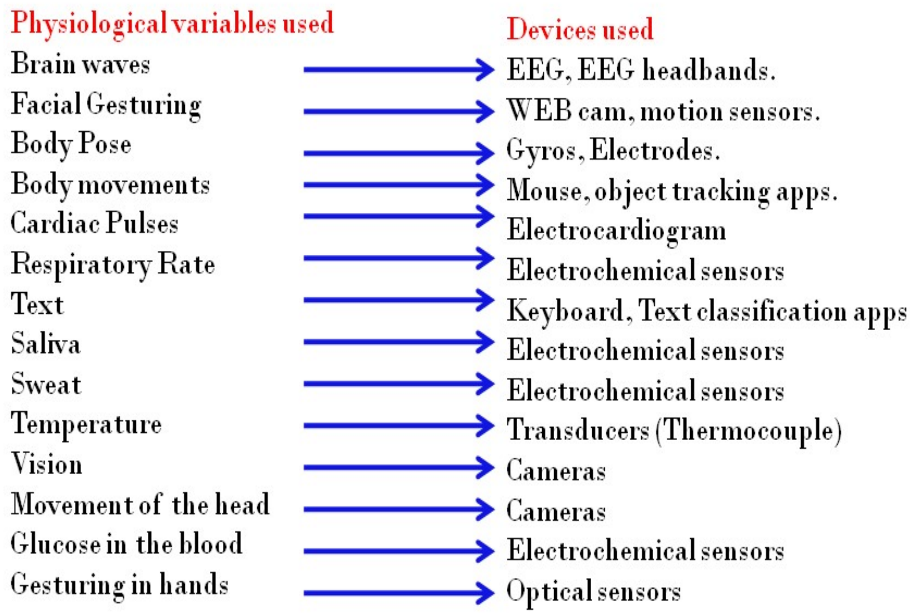

Fig. 3 Devices used to obtain the data of the physiological variables sensed.

Table 2. Comparison of devices, software, sampling time, and effectiveness related to the level of attention.

Database	Facial expression		Number of Subjects
Web Cam Logitech C170 USB 2.0	Open CV C make	1 frame / 64.93 milliseconds	Average detection rate: 84%
Headset headband	Visual Studio C ++	Not specified	The efficiency of binaural sounds: 80%
Bluetooth RFCOMM6 Headband MindWave	MATLAB	Sampling frequency: 512Hz	Not specified
Headband Emotive Epoc	LabVIEW 2010	Not specified	60% writing efficiency using the BCI (Brain-Computer Interface)
Arduino One Electrode helmet	JAVA C#	Not specified	Not specified
Headband Emotive Epoc	WEKA Wizard	2048 Hz 56 data / image	Stays correctly classified: 53.7879%
WEBCAM of PC used for the experiment (variable)	JAVA WEB PHP	Not specified	Accuracy in the recommendation system: 5,757%

WEBCAM of PC used for the experiment (variable)	Face Tracking SDK Kinect for Windows.	Not specified	Not specified
Electroencephalogram Electrocardiogram Prototyping data acquisition card	Prototyping software	Not specified	Not specified
PC used for measurement (variable)	Word NET Word NET Affect	Not specified .	Not specified

3. Methodology.

The research methodology related to this paper is a small-scale, mixed study with qualitative (user´s satisfaction) and quantitative analysis (quality of the products). The analysis was conducted with two groups of college students (control and experimental groups) who carried out web search tasks in small groups of four students each. The actors participating in each group were observed with the participatory observation technique. The homogeneity of the groups was warranted as none of the students had previous knowledge on the search topic; they were also equally qualified in terms of search abilities based on a control test applied. Please note that our goal was not to develop search competency but to contribute positively to the students' attention levels. Therefore, we are not reporting details of the pre-test because it was only used to distribute students in the groups.
The universe of the experiment was all the college students in both public and private schools in the Mexican Republic. The objective of the fieldwork was to verify how the use of a novel website page blocker based on a student-centered design combined with gamification strategies could help students better perform search tasks on the web in the quality assurance course. The fieldwork was carried out at two public and private universities, both being known as the leaders in the region in the universities' index global ranking. Therefore, we defined the population as the college students in these two university systems with more than 200 universities, Puebla, with more than one hundred thousand students. Specifically, 20 students at each university were the samples used.
After applying the pre-test to a total of 40 students, we formulated the following hypotheses:

H0: There are no changes in the before-and-after use of the web Plugin for search tasks.
H1: There are changes in the before-and-after use of the web Plugin for search tasks.

In this case, the mean is chosen as the statistic to be compared; therefore, the hypotheses remain as H0: $\mu1 = \mu2$ and H1: $\mu1 \neq \mu2$. A 95% confidence interval was chosen; therefore, the level of significance is $\alpha = 0.05$. The result of the significance value for the paired samples met the significance of $0.000 < \alpha = 0.05$. The H0 is

rejected, and H1 is accepted if there are differences between before-and-after instructional design, where $\mu1 \neq \mu2$.
From the technological point of view, the development of the web plugin also adopted a formal process fully described in [41] and adapted to the context of the application. The proposed methodology is based on Flow Agile XML, an evolutionary software development process methodology that has come to be agile and has a human-centered design. It has been used for several years to improve the outcomes of projects in terms of functionality but also the documentation. Flow Agile XML spans four phases of development: Initiation, Planning, Executing, and Controlling. The initiation phase is concerned with the understanding of a problem by studying an existing organizational setting; the emphasis is put on identifying the elements involved in the business process description following identification criteria. The output of this phase is an organizational model that includes relevant actors and their respective tasks. From a practicality standpoint, the domain expert describes the business process; from this sketch, the workflow designer identifies the tasks, the resources available to develop them, the units where they are executed, and so on. Afterward, he produces a classification of these concepts, which will be validated for the domain expert.
In the exploratory, an analysis of the context was performed. As the nature of the problem was the attention of college students, the developers were asked to review the literature and web-based solutions. The goal was to be aware of the problem and to get some inspiration. As a result, several alternatives were proposed from a brainstorming session; also, a parallel design session was conducted to finally define the project proposal as a project charter.

3.1The experiment

For the first pilot, the sample was composed of fourth-semester students from the campus of a private university, that is, students between 19 and 20 years of age. A non-random sample of 20 students (6 women and 4 men in both groups) was obtained; therefore, it was a non-stratified convenience sample since they were the students who were easily accessible at that time. The piloting took place in the month of April 2016, that is, in the middle of the semester. The objective of the pilot was to identify the benefits of the solution. Students have major difficulty in solving a simple but not obvious problem to answer the question, "How much does quality software cost? The results were evaluated with simple statistical averages, obtaining as preliminary results the conclusion that the students are more deficient in problems related to the search tasks if there are no controls on their web site browsers.
For the experiment, 80 students from 4 groups were located, i.e., 2 groups from the public university and two groups from the private university. The students were also in the fourth semester on the campus of a private university; that is, the students were between 19 and 20 years of age. They took the test in the month of February 2017.
For the experimental group, one test was designed, although with the same characteristics as the control group, that is, the problems were different in content, but they required a medium-complexity search task.

3.2The page blocker plugin

During this phase, the planning of the project was made based on the information collected during the initiating phase. The activities at this step include requirements elicitation, user stereotypes modeled as PERSONAS, the definition of main documents like the product vision board, the User Histories, the project planning, the budget, and the risk management.

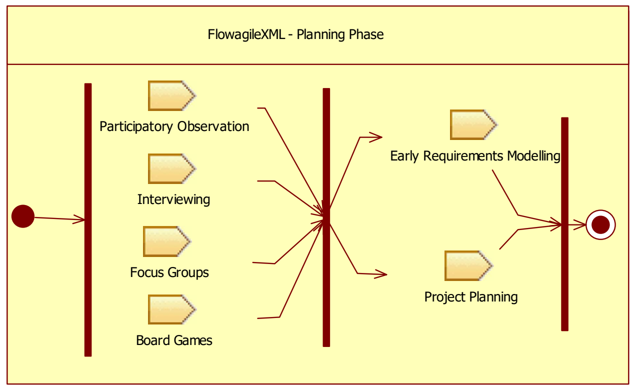

Fig. 4 Activities for the design of the web Plugin, source [GG1]

The requirements elicitation was selected from a focus group technique with college students discussing the pros and cons of using web browsers and being distracted during the class activities.
The Plugin used is internet-based, and, therefore, it is very important to analyze the problem in the context of the internet. The Washington Post asked in an article if “the Internet was giving us all ADHD?” In that article, they described the use case we were trying to address. In it, a person was being productive, and suddenly, they received an email; afterward, they clicked on a link, and then more and more notifications arrived. Focus HD is a web extension that is designed to prevent users from “falling through the rabbit hole.” Essentially, we created a timed web blocker that removes all distractions for the users in a working period of time, with the following features:

- List creation: The app allows the creation of several lists where the user can add sites. The sites can be the ones that distract him or the ones that he works with; then, he can enable or disable them according to the type of work he is performing.
- Timed focused sessions: Once the user has created his lists, he can start a focus session. During the session, the extension will monitor the user traffic and will block potential distraction sites.
- Blacklist mode: In blacklist mode, the user selects the lists that distract him, and those sites get blocked.
- Whitelist mode: In white list mode, the user selects the sites that he uses to work, and the rest of them get blocked

- Statistics: After the focus session is over, the user will see a list of all of the sites that he visited and how much time he spent in each of them. With that information, he can find potentially distracting sites.
- Lives system: Focusing can be hard. Therefore, when the user really wants to go to a site, he can lose a life to interrupt the session. The user gets 3 lives per session, and they last for 5 minutes. This is part of the gamification strategy.
- Sharing system: With Focus HD, you can share your rules with your friends. Just export your list to a file and share them through email or instant messaging. Also, this is a great solution if you have more than one computer.
- Help section: This section contains information about the ADHD disease and the use of the extension.

With Focus HD, you can make two types of lists that allow you to block websites:
Black lists allows you to access every site of the web except for the ones contained in this list. This means, for example, if you have Facebook, Twitter, and Redd it on your blacklist, you won't be able to access any of these by any means as long as the timer is running.
White lists blocks every site except for the ones contained in this list. This means, for example, if you have Stack overflow and Google on the white list, you will only be able to access these sites
The Plugin work as follows: To access the software, the user goes to his browser and locates the Focus HD logo and click son it. A pop up will appear. Then the user locates the Focus HD extension and clicks the settings button for it.
The first step is to make a list. There is a table on the left side in Figure 5, showing all the sites that has been added to Focus HD; these sites will not be blocked. The table on the right side of Figure 5 is the table of sites that are going to be blocked. The user can add sites to his list, and he can also use the remove button to remove a list element or the edit button to edit the site. This is a self-awareness element identified by students who know which sites are not recommended for them; this contrasts with restrictive policies at other universities that simply block sites without seeing the real impact of this during the activities in the courses.
.

Name	Edit	Remove
facebook.com		×

Name	Edit	Remove
google.com		×

Fig. 5 FocusHD creates a table for blocked websites

To move a site from the left table to the right table, the user simply drags the desired site and drops it in the other table. Once the list is made, the user can classify it as Blacklist or Whitelist and click the "Add to list" button. The user can even activate or deactivate the list, depending on his current activities. Another feature designed by the students was to export and import a list.
Last, the Timer allows setting a desired amount of time to focus on work. The popup component is the GUI that the user uses to start and stop training sessions. Graphically, the interface looks like Figure 6.It is crucial to understand that the popup script is not always running. In fact, the scripts are loaded when the user clicks on the

icon, and they are unallocated as soon as the user exits the popup. This is why the code must never assume that the popup will be available at any moment. During the timer, the students are not able to access blocked websites until the time has run out.
To run the timer using their lists, the students have to make sure that the desired blacklist or whitelist is selected and active. As constantly calling the background script through messages can be expensive, we just update the remaining time once with the timer status, and then, if the timer is running, we will set a browser timer that will call a function every second, updating the timer so that the user can see the timer running. It must be noted that this call may not be as precise as the background timer and in some cases, there may be time differences between the popup time and the actual remaining time, however, as we are not expecting to have the popup all the time, the user won´t notice these slight differences. To have this function working properly, we use a function named “bind Update Time,” which, if the preconditions are met, will schedule a call to “update Time” in one second. At the end of “update Time,” if some finish conditions are not met, then it will indirect-recursively call “bind Update Time.”

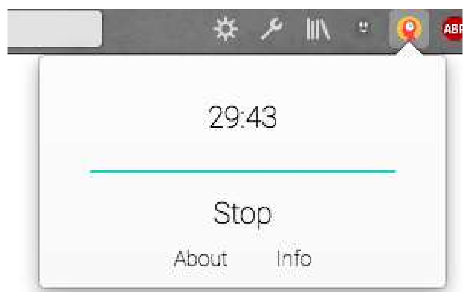

Fig. 6 FocusHD Timer message so hurry and Focus

The timer lives in a file called “background.js.” The timer uses a singleton pattern in order to ensure that at all times, there is just one instance of the timer running. The method that must be called in order to retrieve the instance is “get Global Timer Instance.”
The timer also has a way to notify that it is done. This is to send a message from the background script to the content one. The timer is based on the alarm’s API, which is specialized in using a few resources on time-based APIs. To use this set of APIs, the timer has a unique alarm name defined as “GLOBAL_TIMER_ALARM_NAME.” Also, in order to ensure the correct usage of the API, the binding of the browser should be done by using the “add Listener” method. Another detail that must be noted is the variable “remaining Time.” This variable does not contain the remaining time at all moments. Instead, it is updated every time the timer is started or stopped. In order to get the actual remaining time, the method “get Remaining Time” must be used instead.
Also, the timer implements an observer pattern that allows other components to interact with the timer but, at the same time, invert the dependency so that the timer does not have a dependency on those components. The listeners are available for start, pause, resume, and finish and can be added in two different ways:

Before listeners: They are called before an action occurs. The observers should validate all the conditions, and if they are fulfilled, then they should return true. Returning false from the observe results in the action being canceled and the rest of the observers not being called.

After Listeners (i.e., pause Listener): These listeners are called whenever an action occurs. The result of the observing function is ignored.

Another thing that users can customize is the timer status. For this, they create a decorator function, and every time that the timer gets in that state, it will pass the object to all of its decorators. Last but not least, the timer contains a handler that is responsible for catching all the messages that are sent to it and to call the corresponding actions in the singleton instance. To send any method of the timer as a parameter, you must create a wrapper function that calls the function you want. The reason for this is that the Timer object makes heavy use of "this," but when a method is called without the instance (like "instance.method"), the context is not set, and "this" will refer to the browser window.

The file structure of the plugin allows each component to work as independently as possible. However, total isolation is not possible because of the language (JavaScript), which is not designed as object-oriented, and, therefore, there are functions responsible for connecting the components. The connection between the components is determined by where the component exists, which is defined by the web add-ons structure. Regarding the configuration of settings, each component fetches their settings through the storage API; however, the only component that is currently allowed to modify the preferences is the "Settings" component. In the future, it is expected that some components will store their state on the local storage; however, this will not change the user settings or modify the list of blocked sites.

Messaging is the means of communication for the add-ons between the content scripts and the background scripts. In Focus HD right now, there is only one component that receives messages; however, as we may expect to have other components doing that, we created an expandable model that will allow us to have multiple message receivers without changing the current code. The functions are a first-class member, and therefore, they can be passed as parameters. In this case, sending is an identifier that tells where the message should be forwarded to. Then, the action is the message itself; in other words, the message that we need to send. The last parameter is the function that should be called with the response.

The message dispatcher is a factory-like function which, based on the "sending" parameter, will call the designated handler for the message. Afterward, the handler should only respond to the action and send its response to the function that it is being passed to it. Thanks to this structure, if we need to add another receiver, we can easily do it in the message dispatcher, and if we need to add a new action, we should only do it in the designated function handler.

A setting is a component specialized in managing user preferences. This webpage has heavy use on JQuery, so it is important that whoever maintains it knows exactly how it works. Most of the bindings for the actions on the page are on the very bottom of the file; however, because of some limitations of JQuery, all content that is added dynamically has the bindings created in a function.

The settings are saved at different moments:

1. When the user changes the name of a list.
2. When the list is changed.

3. When any “select” value changes.
4. When the user exits the settings page.
5. When the user clicks “save.”
It is very important to notice that the setting structures in the lists are name-dependent, and, therefore, name collisions should be avoided at all costs. In order to achieve this, every time that the user changes the list name, “get List Name” should be called, which will ensure that these types of collisions do not happen.
When first working on this component, it is very important to take a look at all of the following methods:
1. *fetch Settings*: initializes the components of the setting with the user-saved settings.
2. All methods that have “*save*” in their name: They are the save points for the user data.
3. *add List*: This method contains the list structure, and it is very important to keep it up to date if the structure must change.
The blocker is one of the most important permissions of the app. There are several essential things that happen in the blocker. The first one occurs in “update Lists,” where we compute the active list for the current setting site and then create an array of the selected sites.
Another important concept to understand is how the URLs get parses. Before trying to match any expression or site, we remove some common patterns such as “Http” and “www.” To achieve that, the URL gets sanitized through “get Root Url.”
The method “open My Page” is the one that gets called every time that the user changes the web page or opens a new tab or window. This function works with the API of Firefox, indicating if the request should proceed or be canceled.
Another important piece of the blocker is the functions “search String In Array” and “search Expression,” which check if the current site is on the list. Then, the bridge between the components “should Block Site” will determine what to do, considering if we are using blacklists or whitelists and if the timer is running. Finally, the blocker has a messaging API that allows content scripts to tell it when to load the settings data. The lives component depends on the timer and uses some features in common with it.
Every time the user uses a life, the component will start an alarm with 5 minutes on it. When that time is over, the timer will restart, and a notification will be triggered. The lives component gives the user 3 lives every time he starts a Focus session. The system works because every time the timer is prompt to pause, the before Observer is called, and “can Use Life” is called. There are many other observers that this component listens to in the timer in order to do its job. This component also uses the timer decorator to append the remaining lives to the timer status so other websites can benefit from that information. Lastly, any content script can message the live component to get the number of remaining lives.
The stage includes the activities of research, analysis, and the selection of technologies for the acquisition of physiological data, the emotion model, the educational environment, and the selection and classification algorithms. After the corresponding investigation and analysis, the first three elements of this stage were selected.

3.3Data Collection

The experimental tests were conducted using the MindWave commercial device of the Neurosky Company and MUSE. To obtain the data of brain waves, we developed a graphical interface using the LABVIEW software. In the figure 7 the graphical interface is illustrated on it you can observe the behavior of brain signals. We used traffic light metaphors as feedback for us to identify the attention levels and add some markers to label the data collected. A series of vector swith the sampled data and the variation of the user's attention level are stored.

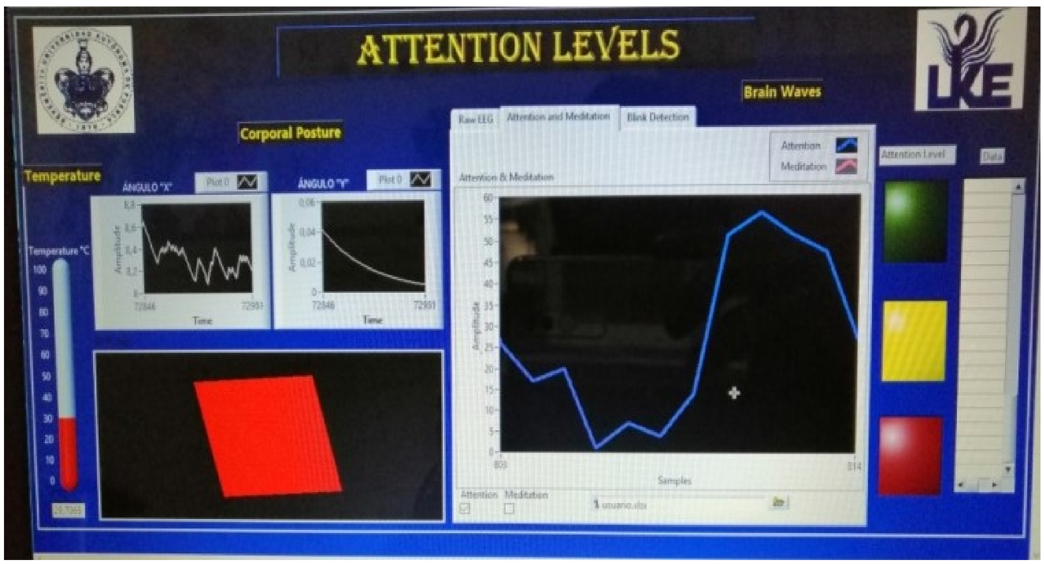

Fig. 7 Graphical interface implemented of the Attention Tracker Monitor

In the functioning of a brain monitoring system, we distinguish 3 main phases, each one with its internal procedures, namely, Signal Acquisition, Signal Processing, and Application.

SIGNAL ACQUISITION. The block where the signal is acquired; it is amplified, and the analog signal is converted to digital signal A / D. The operation of these devices is usually in real-time, but some include the option to record or to register the signal obtained for further study.

SIGNAL PROCESSING. At this point, the interesting features of the digitalized signal are extracted. In this block there are 3 stages:

- Cancellations of Artifacts. Here the noises that come from other bioelectric activities such as muscle movements (these activities are called artifacts) that distort the signal are eliminated.
- Obtaining of Characteristics. The input signal is translated into a vector of characteristics in relation to the neurological phenomenon associated with the signal.
- Translation of Features. Also called decoding, it is where the feature vector is transformed into an appropriate control signal for the device to be controlled.

APPLICATION. It is the block in which the control signal is received and performs the corresponding actions on the device through its controller [57].

Figure 8 shows a schematic of the process, detailing its blocks and stages, for a better understanding of the BCI operating principle. The BCI (Brain-Computer Interfaces) are devices that are relatively new implantations in the mass consumer market since the main function that they carry out has been used for many years in the field of medicine. These devices usually have a shape that goes from a headband to something like a "semi helmet." They are advertised mostly as a gadget, which serves, among other things, to play, to "control" other devices, and mostly, to take control and, therefore, train your brain in terms of relaxation and meditation [46].

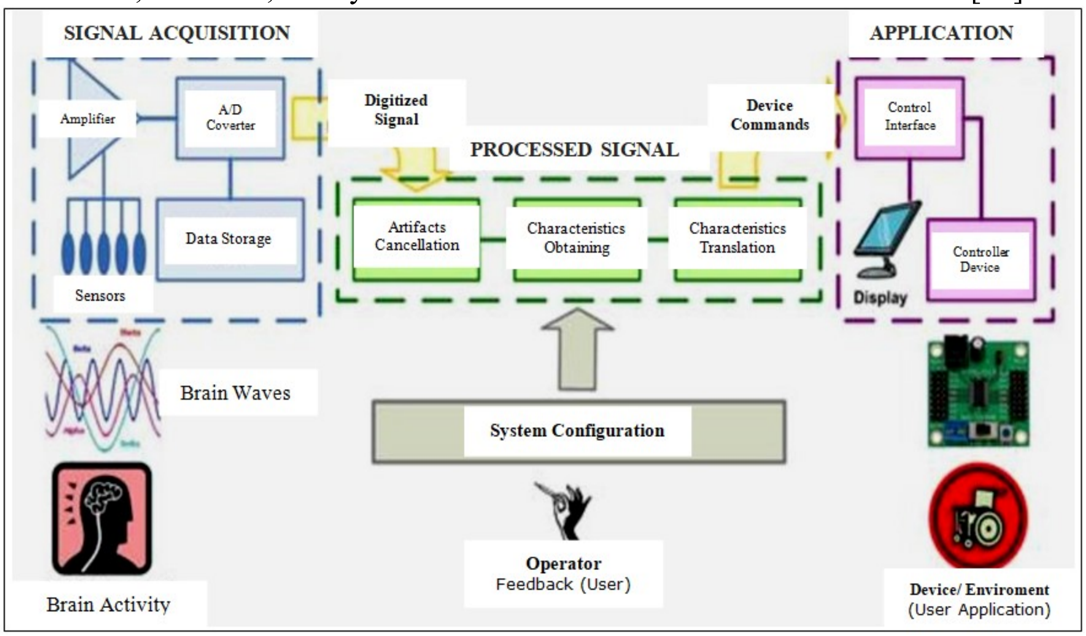

Fig. 8 Schematic of the functioning of a cerebral monitoring system

For this reason, the shapes they have are simple and attractive for the potential buyer, differing a lot from the typical electrodes that stick to the scalp with some conductive gel, which have been used historically to perform Electroencephalograms in the medical field. There are different types of BCI, which have particular characteristics in their designs. Table 3 describes some important technical characteristics of two different BCI devices used, such as number and type of sensors, price, and the option of a software development kit (SDK).

Table 3. Table of Comparison of the brain-computer interfaces.

Device	Price (Dollars)	Electrodes	Mental States	SDK	Released	Producer	Interface
MindWave	$99.99	1	2	YES	2011	NeuroSky	Bluetooth
Muse	$299	4	5	YES	2014	InteraXon	Bluetooth

The headbands have specific characteristics; the performance of each depends on the application that you want to perform. MindWave is the most versatile headband even if it only has one sensor. It is the ideal headband to monitor the level of attention. Muse is the headband with the longest sampling time despite having four sensors.

4. Results and Discussion

Here we present the results of the statistical analysis performed on the samples obtained from the brain waves belonging to the students. The first user result we created was with a group of users who were together and had a specific team task to achieve. In this case, the list was predefined. In this exercise, we found a bug related to the login that made the experiment difficult. Also, we found that the list was not complete for the users we were testing on. However, we discovered that the group of people was more distracting than the internet itself; therefore, the app was not useful in this context.

The second round of user tests was made in a group of people where everyone was asked to install a special version of Focus HD with a predefined set of sites that included social networks and the most popular entertainment sites. The individuals were asked to perform a task that required a lot of research, namely, to find out how many resources should be spent on software quality. The result was that the students got to the number very quickly compared to previous generations who took a long time or did not even find the result at all. Analyzing the statistics obtained during this test, we found out that the users visited a lot of research sites; also, we found that they moved through the sites quickly (less than two minutes) in most of the sites.
Another finding was that some users changed the times in their machines in order to tamper the system (which worked). This fact is important as it shows that Focus HD is meant for users who want to concentrate; unwilling users will find workarounds to it.
Finally, we got a score of SUS of 44.06, which tells us that the application helps the user in some ways to maintain attention, but also, it tells us that we still need to work a lot in perfecting this add-on, especially its usability.

4.1 Results of the attention level of those working in teams

Preliminary results showed that (1) students with the plugin finished their work sooner; (2) the quality of the work in the experimental group was as good as the control group, and (3) in the control group, it was normal that some teams did not finish the activity correctly on the experiment, while this was not the case for any team in the experimental group. On the qualitative side, the following observations were made: (1) the searcher's attitude changed positively with the web plugin, and (2) the students' satisfaction increased. Last, the experiment collected data to document searcher behaviors, such as EEG, speaking, and facial expressions. This study was carried out with two groups of students at an undergraduate level in one public and one private university. In both universities, each group was part of a course called "Software Quality and Testing."They received project-based learning and were used

to working independently and collaboratively in the classroom and at home. The control group used the web browser without any manipulation, while the experimental group used the web plugin to block certain websites. The classes or groups were convenience samples. To measure students' attention and the quality of the results, we used observation and EEG tracking as rubrics for the quality of the work and qualitative tests to elaborate more on the observations. While the activity was being carried out, 5 students were monitored randomly, where their attention level was obtained for 10 minutes; the feedback was observed in another independent room through a physical traffic light, and a laptop which received the data sensed with the MindWave headband and MUSE, which described the level of attention of the student in each sampling. Samples were taken every 500 milliseconds with instant feedback to the person who monitored the activity in an isolated room. The average of the samples of each of the students monitored was52.97%, which contrasted with the students without the plugin, who had a much lower average, 32.32%.
On the emotions and data collection analysis, it was not clear that the students were much more focused, as they had finished the activity in less than half of the originally estimated time. Consequently, they were more than happy, motivated, and enthusiastic about the benefits of using the plugin because they had more spare time in the end, or they could leave the class early. We need to say that the search activity is something that we have given to students every year, and, on average, one-third of the student teams found the right solution, one third got an approximate solution, and one-third of the teams failed in the activity. During the experiment, the result was the same, but, surprisingly, the teams using the plugin finished the task correctly. This was totally unexpected and clearly motivates us to continue our research.

5. Conclusions

Attention in the classroom is needed to accomplish learning goal success fully. There are different theories and strategies to help students become focused, but in today´s context, with the use of technology as a means to work, the devices can be a source of distraction to students. The question addressed in this work was how to keep the students' freedom to use technology in the classroom properly? How to create a solution to keep them focused on search tasks? A web plugin made by students for students was created as an alternative to help students to be focused while performing search activities. The results of the use of this plugin showed that the quality of the results is much better compared to those without the plugin, the students' satisfaction increased significantly, and their attention levels were higher. Although these results may not be conclusive, they clearly encourage us to keep working on novel technology to assist students in the classroom. The developed mechanism to measure attention also needs refinement. Simpler and less intrusive hardware is needed to track the students' attention more naturally. As future work, we want to incorporate body posture as a parameter of attention, for instance, tracking movement to detect abnormal activities.

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