EARLY CHILDHOOD EDUCATOR ASSISTANT WITH BRAIN COMPUTER INTERFACE

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Abstract

Education is the most important investment in the modern and complex industrial country. Currently, there are numerous methods to track and grasp how well a child is able to concentrate during lessons. However till date, there are still very limited studies in implementing adaptive self-learning techniques to suit the needs and preferences of each child for better learning experiences. Early Childhood Educator Assistant with Brain Computer Interface (BCI) is an interactive self-learning system capable of monitoring the learning capabilities of children and providing feedback by using visual optimization such as short video clip playback if the concentration of the child drops. An adaptive self-learning system able to change the learning content difficulty based on scores of children towards the lesson. The Emotiv neuroheadgear will detect EEG signals emitted from the scalp then be further processed to determine the state of mind and engagement levels of the child so that feedback can be sent based on the varying conditions. This system has been tried and tested with a group of children between the ages of 4 to 6 years old and shows an improvement in the engagement levels.

1 INTRODUCTION

According to a study from the National Institute of Child Health and Development[1], many children are having learning disorder problems especially in developing countries. Children with learning disorders usually have symptoms such as difficulty in reading, writing and memorizing. For those children without learning disorders, concentration and boredom levels also affect the learning process. The concentration and boredom levels are mainly influenced by the behavior of each particular student. Children with faster learning capabilities than others will find the lesson too easy and prevents them from reaching higher potential. On the other hand, children with slow learning capabilities will lose interest in the lesson.

Dealing with the aforementioned problem, emotion education research[2] has grown significantly over the years in order to help improve the learning experience for children. There are many methods to detect the children learning process via brainwave monitoring system. However the method to solve these effects is rarely researched on. Besides that, active learning applications using brainwave analysis are widely available in the market but existing applications do not provide feedback to users. Besides that, existing system in the market only monitoring the children brainwave without optimize the brainwave immediately.

One of the solutions is by implementing an adaptive self-learning system. The system involves brainwave monitoring capabilities based on the engagement level of the children by utilizing visual optimization using video clip for attracting concentration of the children and making the learning process more interesting. Based on a research done by The University Sydney, close to 70% of the students are able to improve concentration levels when watching short clips during lessons[3]. Brainwave educator assistant with brain computer interface is aimed to be adaptive and interactive to attract the concentration of children during lesson. A video will be displayed when the student's concentration level drops. Data can be stored into the database for further analysis. In the end of the project, the system can be used as an education assistant to help the children learn better during mathematic lesson as a start.

2 Background on Brainwave

The human brain is made up of billions of brain cells called neurons [4]. The function of neurons is to transmit information throughout the human brain and body while communicate with other organs. A neuron[5] can be divided into three different parts which are cell body, dendrites and axon as shown in Figure **1**. The electrical signal sent by a neuron will be received at the dendrites of another neuron.

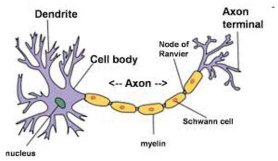

Figure 1: Structure of Neuron[6]

2.1Electroencephalogram (EEG) signal

The electrical signal generated by a neuron is known as electroencephalogram (EEG) signal. The EEG signal is measured based on the voltage fluctuation level across the scalp when a signal is transmitting between neurons. The amplitude of EEG signal is very small within the range of 0-100 microvolts (μV)[7]. The frequency range is from 0.1Hz to 100Hz. Table 1 shows the summary of classification of five different types of EEG signal.

TABLE 1: : Classification of Five Different Brainwaves[8]

Signal	Amplitude	Frequency	Condition
Delta	Highest	<3Hz	• Deeply sleep • Coma patient
Theta	Higher	3.5Hz to 7.5Hz	• Drowsy • Dreaming
Alpha	Medium	7.5Hz to 13.5Hz	• Very relax • Meditation
Beta	Low	14Hz to 30Hz	• Engaged

Gamma	Low	>30Hz	• Hyper brain of activity

2.2EEG Brainwave Signal Detection

The 10/20 System is an internationally recognized method to describe the location of scalp electrodes. The distances between adjacent electrodes are either 10% or 20% of the total front-back or right-left distance of the skull.

TABLE 2: Identification Acronyms for the 10/20 System

Electrode	Lobe
F	Frontal
T	Temporal
C	Central
P	Parietal
O	Occipital

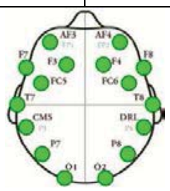

Figure 2: EEG Signal Points in Head Scalp[9]

2.3Emotiv EEG Neuroheadgear

Emotiv EEG is the nueroheadgear used for high resolution, neuron signal acquisition and processing applications. The device consists of 14 saline sensors with 2 reference points. The device can detect raw EEG data which can be used for research and analysis.

3 early childhood Educator assistant with brain computer interface

Early Childhood Educator Assistant is a system designed to boost the speed of learning process and the effectiveness of the childhood educator system using brainwave. This system is designed to target the children between the aged of 4 to 6 years old. The systems consist of brainwave monitoring capabilities and optimize the children engagement level in order to improve the learning process. The entire system can be broken down into 2 main sections which are the internal system operation and the graphical user interface (GUI).

3.1Early Childhood Educator Assistant System Operation

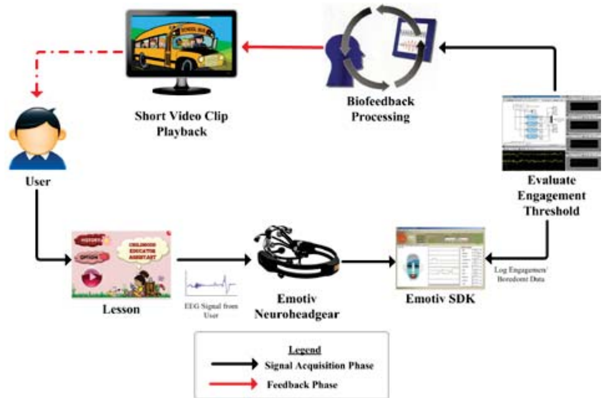

Figure 3: Block Diagram for Brainwave Educator Assistant

Early childhood educator assistant with brain computer interface is an interactive self-learning education system with the capabilities to monitor engagement level of children throughout the learning session. Moreover, the system will adaptively change the learning content according to the children's affectiv and performs brainwave optimization or provides some visual entertainment such as short video clip playback.

The block diagram Figure 5 shows that EEG signals are acquired via the Emotiv neuroheadgear from the scalp of user when the lesson starts. MATLAB is the software platform used to carry out final classification processes by evaluating the child's engagement level based on the preprocessed signals by Emotiv SDK [10]. After that, engagement data will be logged into MATLAB for processing. The large set of engagement data will undergo interpolation in order to reduce the number of data. Next, the system will interact with Emotiv SDK to determine the child's engagement level. At this state, the system can improve the child's engagement levels and focus based on the feedback generate by the brain. If the engagement level of the children drops below certain level, the system will be optimized the children engagement level using a short video clip playback to attract the child towards the learning material. Continuous monitoring and data acquisition is done in order to examine the child's respond towards the learning material.

The flow chart of Early Childhood Educator Assistant is shown in Figure **4** below. First of all, Emotiv neuroheadgear, Emotiv SDK and MATLAB are required to initialize before the application starts. Emotiv EEG neuroheadgear requires 3-5 minutes to allow all the electrodes to detect the scalp of the user for signal acquisition. Once the lesson GUI is loaded, the main page will be displayed and prompt the user to start the lesson. Next, raw EEG signals are being detected and retrieved. The raw EEG data is sent to Emotiv SDK for signal processing procedures such as signal de-noising and feature extraction. The output of the SDK will then interface with MATLAB for data logging. The large number of data undergoes linear interpolation to decrease the original sampling rate of a sequence to a lower rate.

After that, the mean of the overall engagement data will be calculated and the mean value will then be compared with the engagement threshold. The threshold is set based on the default engagement value for Emotiv SDK [11, 12]. If the mean value is greater than the engagement threshold, the system will proceed to check the number of questions. Inversely if the mean value lower than the engagement threshold, then the system will play a short video clip to attract the attention of the child towards the lesson. The system continues in a loop and will only break free after the user successfully answers ten questions. The total lesson scores and the average engagement level in percentage will then be displayed in the final GUI. At the end of the learning process, the summary of results can be saved into an excel file for future reference.

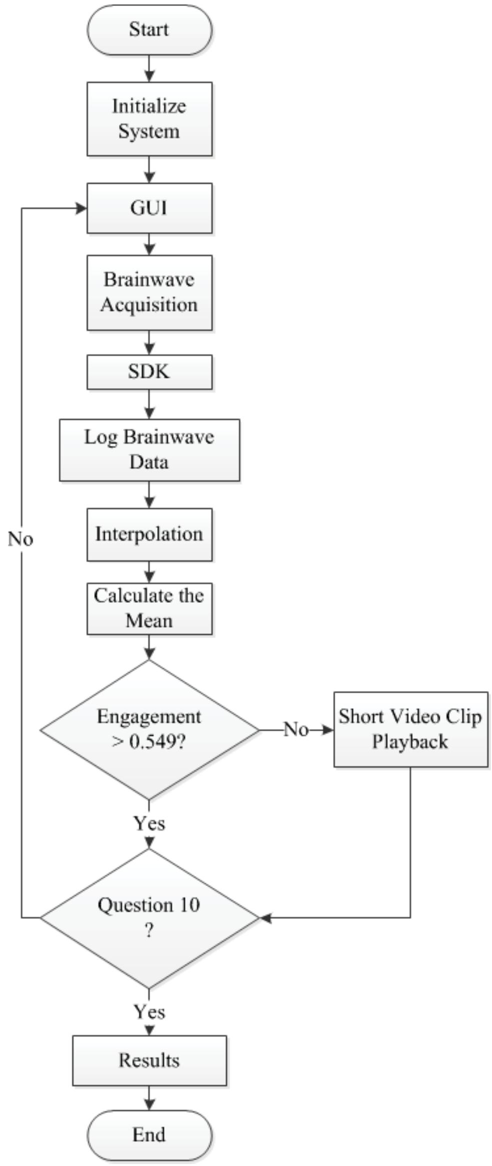

Figure 4: Main Flow Chart

3.2Graphical User Interface

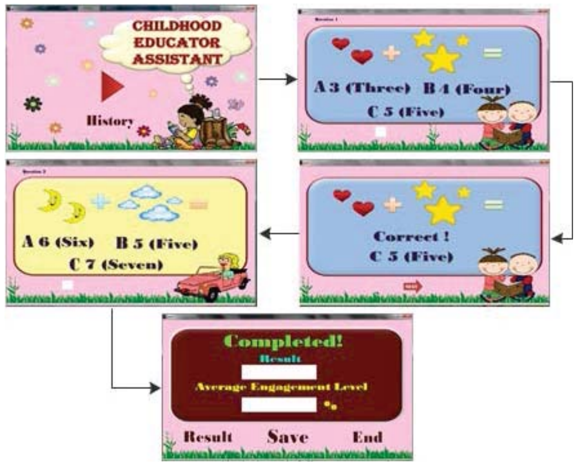

Figure 5: Graphical User Interface

Once the GUI is loaded, the main page will be displayed and prompt the user to select between two options which are starting the lesson or the history button respectively. The user history database will be read from the excel file when the history button is selected. On the other hand, the lesson starts when the start button is chosen. The brainwave of the children will start to acquire and monitor once the lesson is start in order to optimize the children engagement level to the optimum point until the end of the lesson. At the same time, the user will then be required to answer a set of pre-programmed questions. After every question, if the user has got the right answer then the GUI will display “Correct” and the answer selected. Inversely, if the answer is wrong then the GUI will display “You are wrong” and the correct answer will be shown. The GUI will be proceeding to next question until end of the lesson. If the system detecting the engagement level of the children drops then a short video clip will be displaying to attract the children back to the lesson GUI.

Lastly, the total score of all the questions and the average engagement level throughout the lesson will be shown in the final GUI. The user can then choose to save the data by writing into excel file for future reference. The system will stop if the option “end” is selected. The design of the GUI revolves around providing an interactive user interface to provide children with an attractive learning medium and making learning process fun.

4 Experiment and analysis

4.1Analysis on Power Density Spectrum for Different Channels

The aim of this experiment is to determine the engagement/boredom levels of the user based on the power frequency spectrum. This experiment also aims to show if all electrodes are needed in detecting and determining the emotion levels. This experiment has been carried out with 20 different subjects. The similarity of result is determined by calculating the ratio of the EEG band. The Emotiv neuroheadgear uses the 10-20 electrode placement method in designing the location of all 14 electrodes[13]. Regardless of the number of electrodes, raw EEG data obtained will still undergo signal processing before obtaining a cleaner signal with less noise. The output of this EEG signal will then be broken into delta, theta, alpha and beta waves where each wave has different frequency range and amplitude for different type of activity. Based on a research from Cleve Labs[14], theta and alpha waves are most easily obtained from the occipital lobe while beta waves are more easily recorded at the parietal and frontal lobes. Therefore, by reducing the number of electrodes the resulting EEG data will be much more accurate to determine the engagement level[14] and also reducing the processing time. In this experiment, two different numbers of electrodes namely 8 electrodes and 14 electrodes has been carried out respectively. Table 3 below is the position of the 8 electrodes that used for analysis that consist of strong theta, alpha and beta wave which is required to analyze engagement.

TABLE 3: Electrode Numbers

Channels	Position
14	AF3, AF4, FC5, FC6, T7, T8, F7, F3, P7, O1, O2, P8, F4 and F8
8	F7, F3, P7, O1, O2, P8, F4 and F8

Engagement Level Ratio is calculated. The blue colour line is record when children are engage and the ratio is 0.017 while the boredom ratio for red colour line is 0.006.

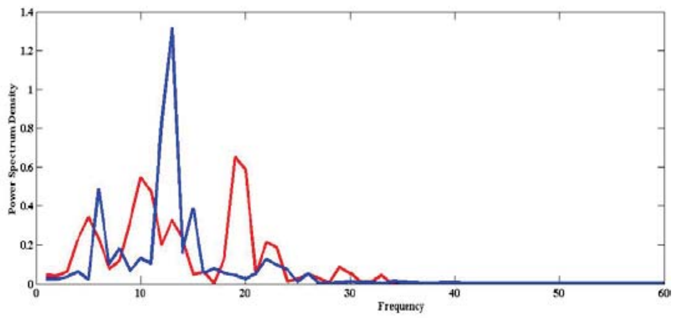

Figure 6: Power Density Spectrum for 14 Channels

Engagement Level Ratio is calculated. The blue colour line is record when children are engage and the ratio is 0.017 while the boredom ratio for red colour line is 0.005.

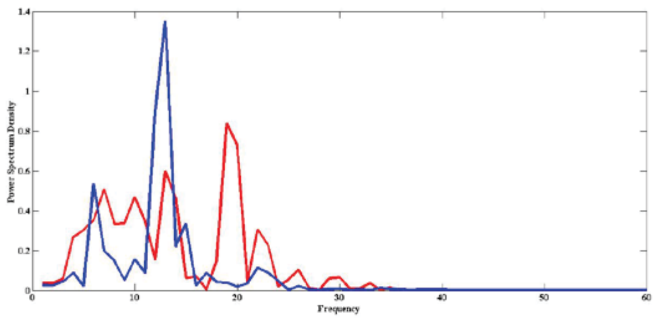

Figure 7: Power Density Spectrum for 8 Channels

The ratio of engagement can be calculated from the equation $Engagement = \frac{\beta}{\alpha + \theta}$ (1). The results show that some channels can be eliminated and still obtain similar results. By reducing the number of channels, data processing time will be faster as there is less data available. Based on the analysis, the highest power for the boredom frequency spectrum mainly ranges from 10-13Hz (alpha band). In additional, the power of alpha waves is much higher than that of beta waves because alpha waves have low frequencies thud higher amplitude. Alpha waves are consistent with relaxation and minimal body movement which proved the theoretical concept.

4.2 Analysis on the Effect of Short Video Clips on Children Brainwave

The aim of this experiment is to analyze the change of children's brainwave when different types of video clips are played. Four different types of short video clips are selected to test on 20 kindergarten kids between the ages from 4 to 6 years old. By doing this experiment, the videos that are able to engage the children will be used as the database stimulus for brainwave educator assistant. The 50000 data will be recorded from the output of the SDK for analysis while the video clips will be played continuously for 1 minute. The output of SDK is has been normalized in the range from 0 to 1. 0 is the highest boredom and 1 is the highest engagement. After that, the mean value of 50000 data based on 20 kids will be calculated for each of the video clip.

TABLE 4: Mean Value of Each Video

Video	Mean
1	0.8086
2	0.4722
3	0.8098
4	0.4035

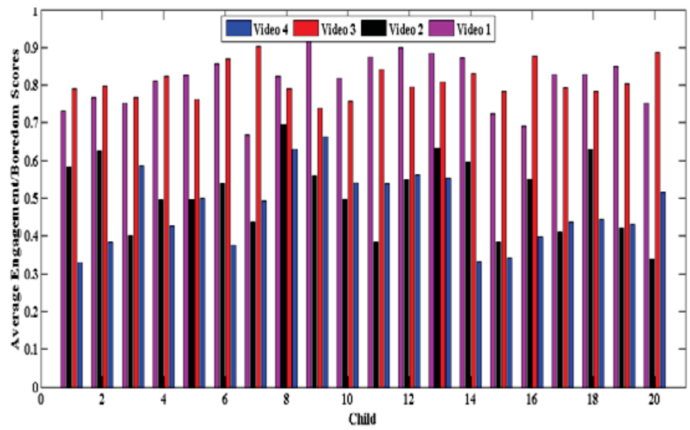

Figure 8: Average Engagement/Boredom Scores based on Four Different Videos

Emotiv SDK normalized scores for engagement and boredom is between the ranges of 0 to 1. The result shows that video 1 and video 3 can be used as the database for brainwave educator system because children have the highest engagement results which exceed 0.549. When the children's engagement level drops below the threshold, a video will be played to attract the children towards the lesson.

4.3 Analysis on the Effectiveness of the Early Childhood Educator Assistant

The effectiveness of the system is determined based on the comparison between the total scores of the lessons with and without the system. The exercises are distributed to 40 subjects aging from 4 to 6 years old at the Growing Moment Kindergartens. First of all, the subject is required to answer a set of questions on paper and also a set of questions using brainwave educator system. The Mathematic questions are specifically designed for children and make the questions as interactive as possible to attract children towards the lesson. According to research, analysis shows that most of the children are able to learn more effectively by using visualization methods. Therefore, the questions set utilize images as a form of teaching medium. During question answering, the child's brainwave will be acquired continuously. The average engagement level throughout the lesson is recorded. The improvement of the system compared to the conventional education method is calculated based on the engagement level of the children and also the total scores that achieved by the children.

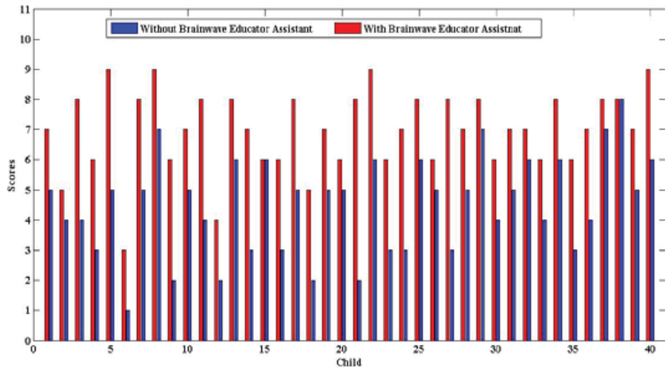

Figure 9: Scores with and without the System

$$\text{Average Scores} = \frac{(Total\ Number\ of\ Scores)}{(Total\ number\ of\ Subjects \times Number\ of\ Questions)} \times 100\% \quad (2)$$

TABLE 5: Mean Value for Each Video

	Brainwave Educator Assistant	Conventional Education System
Average Scores (%)	69.75	45.00
Improvement (%)	24.75	

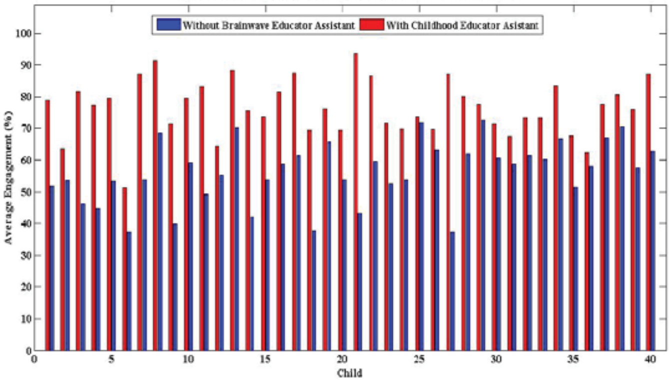

Figure 10: Average Engagement with and without the System

$$\text{Average Engagement} = \frac{(Total\ Engagement\ level)}{(Total\ number\ of\ Subjects \times 100)} \times 100\% \quad (3)$$

TABLE 6: The Effectiveness on Average Engagement Level

	Brainwave Educator Assistant	Conventional Education System
Average Engagement (%)	76.51	56.20
Improveemnt (%)	20.30	

Based on the analysis, the aim of the experiment is achieved. Early childhood educator assistant able to improve the overall scores and average engagement of the lesson. Most of the children are able to focus when using the system because the GUI is specifically designed to target children. This analysis shows that children are able to score better when the engagement of the children is higher. Besides that, the result prove that the short video clip playbacks are able to attract children to focus again. This system helps children learn better by improving the engagement levels by 24.75% compared to the conventional method while the engagement level of the children using the system can be improved by 20.30%. The aim of the early childhood educator assistant is to develop an interactive self-learning system using brainwave optimization that improve effectiveness of learning processes.

5 Conclusion

In this paper, early childhood educator system has been developed and tested with 40 children. The results show the EEG data obtained from 8 and 14 electrodes are similar. This is due to engagement level is most strong to detect in frontal, occipital and also parietal regions of the brain. Furthermore, this paper demonstrates the children are more engage to visualization therefore short interactive clips are selected as the database. Finally, the system has been tested and proven to be able to improve the engagement levels of children during learning process. As a conclusion, the experiment proven that children with high engagement levels will improve the learning process become more effective.

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