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Deep Learning on EEG Study Concentration in Pandemic

Garnis Ajeng Pamiela [1], Ahmad Azhari [2,*]
Department of Infomatics, Faculty of Industrial Technology,
Universitas Ahmad Dahlan, Yogyakarta, Indonesia
e-mail : garnis1700018223@webmail.uad.ac.id [1]; ahmad.azhari@tif.uad.ac.id [2];

ABSTRAK

Brainwaves are one of the biometric properties that can be used to identify individuals based on their physical and behavioural characteristics. An electroencephalogram (EEG) can be used to measure and capture brain wave activity. The activities required are in the form of giving complex tasks to get thinking and concentration processes called Cognitive Tests, in the form of a Culture Fair Intelligence Test (CFIT) stimulus and Competency Test (UK). This study aims to obtain a pattern of the relationship between concentration and learning outcomes for late adolescent students during the pandemic. The object of research involved in this research is the 10th grade students of TKJ SMK. Data acquisition was carried out twice on the Beta signal by doing cognitive test questions which were done twice at school and at home. Then the data obtained from the test results will be extracted using Fast Fourier Transform (FFT). Furthermore, after the data extraction results are obtained, the classification process will be carried out using the CNN algorithm. The results of the FFT obtained the average value of the signal peak. The results of the CNN classification show that the pandemic does not affect student concentration. The average signal concentration in schools when testing using CFIT is 0.2445 and at the time of testing using UK Mathematics is 0.1330 with an average CFIT score of 77.05 and for UK average is 53.33 with an accuracy value of 83.33 %. While the average signal concentration at home when testing using CFIT is 0.2252 and at the time of testing using UK Mathematics is 0.1301 with an average CFIT score of 77.13 and for UK average is 57.50 with an accuracy value of 83, 33%.

Keywords - Brainwaves; Electroencephalogram; Deep Learning; CNN; Fast Fourier Transform

1. INTRODUCTION

The development of technology today is growing quite rapidly. With the development of technology, now there are many technologies that can be used to help and alleviate various kinds of human work in all fields. Technology is widely used in various fields including in the fields of Agriculture (K. Nugroho, D. Widyajayantie, S. A. Ishthifaiyyah, and E. Apriliani, 2021), Education (S. Shrader et al, 2016), Culture (P. J. T. Haryani, 2017), and Health. In the field of Health, technological developments are used to create medical devices such as Electrocardiogram (ECG), Electromyogram (EMG), and Electroencephalogram (EEG) (P. . Puspitaningayu, A, 2018). In the health sector, the use of technological developments is used to carry out the process of identifying a disease. In the application or use of existing tools, of course, it cannot be separated from the role of expert doctors or those concerned in the health sector.

EEG is a technique for measuring electrical activity on the scalp produced by brain structures taken with metal electrodes and conductive media. EEG was recorded in animal brains in 1875 by Richard Carton. Then in 1924 for the first time EEG was introduced by Hans Berger to record signals in the human brain (D. Millett, 2001). EEG is a signal acquisition method that is most widely used because it has a high temporal resolution, a technique that is relatively easy and safe to use communication that occurs in human brain cells takes place through electrical impulses. This was measured by placing electrodes on the subject's scalp. EEG is usually used to diagnose, monitor and analyze various abnormalities in the body, especially in the brain. One of the main uses of EEG is to diagnose epilepsy (P. Jayakar et al, 2016). In addition, EEG can also be used to study or perform therapy on children who suffer from Autism, or also on children who have learning difficulties (Learning Disability) (S. A. Nugraheni, 2016).

Learning disability is defined as a change in behaviour that occurs in a person continuously which is not caused by the presence of an illness or fatigue (K. E. Stanovich, 1999). Characteristics of a child who has learning difficulties (Learning disability) usually has low perceptual abilities (poor perceptual abilities), difficulty realizing one's own body (body wariness difficulties), movement disorders (disorder of motor activity), and difficulties in psychomotor skills. The causes of learning difficulties in children arise from several factors, namely organ factors (organically based etiologist), and environmental factors (environmentally based etiologist). Learning difficulties (learning disorder) from environmental factors, one of which is caused by emotional influences, a child with emotional problems usually tends to have weakness and perception, speech and is weak in academic subjects. In the case of the environment, the cause of learning difficulties is a lack of handling (poor teaching). Based on the concept of delay in self-maturity in terms of neurological development aspects, a child has different levels, including cognitive function (M. N. Ghufron and R. Risnawita, 2015).

*) Corresponding Author

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Now almost every country in the world is being hit by the Covid-19 outbreak. Covid-19 is a virus that spreads very quickly and is a deadly virus, for those countries in the world are busy in setting various policies as an effort to break the chain of the spread of the corona virus, Indonesia is no exception. Indonesia itself has several times set a policy of Restricting the Movement of Community Activities (PPKM) which is applied to each region. This policy resulted in major changes, such as in the economic sector, in the health sector, and in the education sector. In the field of education, the government through the Ministry of Education and Culture (Kemendikbud) strives so that education actors such as educators and students can still organize teaching and learning although in different ways. The Ministry of Education and Culture encourages the implementation of the teaching and learning process to be carried out online (on the network) (Asmuni, 2020). In the implementation of online learning, it presents its own challenges for education actors, such as educators, students, institutions and even provides challenges for the wider community such as parents. In practice, educators must find ways to continue to deliver learning material and be easily accepted by students. Likewise, students are required to be able to adapt to situations and conditions like today, one of which is mental readiness (U. Hanifah Salsabila, L. Irna Sari, K. Haibati Lathif, A. Puji Lestari, and A. Ayuning, 2020). In the implementation of online learning, it presents its own challenges for education actors, such as educators, students, institutions and even provides challenges for the wider community such as parents. In practice, educators must find ways to continue to deliver learning material and be easily accepted by students. Likewise, students are required to be able to adapt to situations and conditions like today, one of which is mental readiness (U. Hanifah Salsabila, L. Irna Sari, K. Haibati Lathif, A. Puji Lestari, and A. Ayuning, 2020). In the implementation of online learning, it presents its own challenges for education actors, such as educators, students, institutions and even provides challenges for the wider community such as parents. In practice, educators must find ways to continue to deliver learning material and be easily accepted by students. Likewise, students are required to be able to adapt to situations and conditions like today, one of which is mental readiness (U. Hanifah Salsabila, L. Irna Sari, K. Haibati Lathif, A. Puji Lestari, and A. Ayuning, 2020).

Therefore, to find out whether children are having difficulties in learning during the pandemic, it can be seen from the time that children need to understand a problem. To find out how much the child's brain ability to beat learning difficulties can be tested with psychological tests, one of which is the Culture Fair Intelligence Test (CFIT). Based on the problems that have been described above, this study aims to obtain a pattern of student concentration during the pandemic on learning outcomes. In this study, researchers will use a tool called Neurosky Mindwave Mobile 2 which will be installed on the head without having to go through skull surgery. So that it is easier to use and safe to use and does not pose a risk to the subject to be studied.

2. LITERATURE REVIEW

A. Brainwaves

Brainwaves in humans are generated by the activity of neurons in the human brain, the activity of these neurons produces electrical signals as information and motor carriers. The waves generated by the human brain when carrying out an activity have a frequency range of 0.5 Hz to 50 Hz. The waves produced by the brain when carrying out activities can be divided into 5 types of EEG signal patterns, namely Alpha, Beta, Theta, Delta, and Gamma. Each brain wave has different characteristics and indicates a person's mental state (A. Azhari, 2017). The types of brain waves and their frequencies can be seen in Table 1 Types of Brain Wave Frequency (A. Azhari, 2017) below.

Table 1. Types of Brainwave Frequency

Wave Type	Frequency	Mental Condition
Delta	0.5 – 4 Hz	The state of deep sleep without dreaming (Deep sleep). Rest phase for the body.
Theta	4 – 8 Hz	Meditation, intuition, and fantasy states.
Alpha	8 – 15 Hz	A state of relaxation and wakefulness.
Beta	15 – 32 Hz	Conditions of focus, thinking, and concentration. Productivity phase for the body.
Gamma	32 – 50 Hz	Conditions of high mental activity such as fear, panic, or competition.

Giving activity during the EEG process will affect the pattern of brain waves that are formed. In this study, the concentration of the subject is the main focus in the data collection process. Concentration itself enters the Beta signal pattern, because Beta wave signals are brain waves that appear during conditions of thinking, focus and concentration, Beta waves also aim to help humans maintain focus when doing an activity that requires concentration in it.

B. Concentration

Concentration is a state in which thoughts or conditioned associations are activated by sensations in the body. To activate sensations in the body, a relaxed state and a pleasant atmosphere are needed, because in a tense state a person will not be able to use his brain optimally because the mind becomes empty (A. Nuryana, 2010). A pleasant atmosphere in this case is meant in the condition that a person is in

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a very relaxed state, there is no tension at all that threatens him both physically and non-physically [19]. Concentration can also be interpreted as a person's ability to focus his attention on an activity or stimulus in a certain time (F. A. Nisa and N. Khotimah, 2019). Concentration when studying or doing other activities is important. That's because concentration is the most important factor to achieve maximum learning achievement. The environment can also affect a person's ability to concentrate, but everyone can have a different way of concentrating. There is someone who can concentrate by listening to music, studying in crowded places, and hanging out with friends. However, there are also those who can only study in a quiet place without sound, or there are also those who can study in a place under any circumstances. The concentration power of adults to listen ranges from 25 to 45 minutes, while for children it ranges from 15 to 25 minutes but everyone can have a different way of concentrating from each other. There is someone who can concentrate by listening to music, studying in crowded places, and hanging out with friends. However, there are also those who can only study in a quiet place without sound, or there are also those who can study in a place under any circumstances. The concentration power of adults to listen ranges from 25 to 45 minutes, while for children it ranges from 15 to 25 minutes but everyone can have a different way of concentrating from each other. There is someone who can concentrate by listening to music, studying in crowded places, and hanging out with friends. However, there are also those who can only study in a quiet place without sound, or there are also those who can study in a place under any circumstances. The concentration power of adults to listen ranges from 25 to 45 minutes, while for children it ranges from 15 to 25 minutes.

C. Culture Fair Intelligence Test

Psychological tests are objective measuring tools that have been standardized or standardized in terms of measurement based on certain behavioral examples. Psychological tests can also show various psychological aspects for someone who does it (R. Saptoto, 2018). In measuring a person's intelligence, of course, a psychological test is needed. One of the intelligence tests currently being used is the Culture Fair Intelligence Test (CFIT), this CFIT test was developed by RB Cattell based on his views on intelligence. CFIT itself consists of three types of tests or scales, namely scale 1, scale 2, and scale 3 which can be seen from Table 2 of the CFIT Scale.

Table 2. CFIT Scale

Scale	Information
1 scale	Used to measure the intelligence of children with an age range of 4-8 years and older people who have learning difficulties.
2 scale	Used to measure the intelligence of children with an age range of 8-14 years, or adults who have normal intelligence.
3 scale	Used to measure the intelligence of children with an age range of > 14 years or adults who have superior intelligence levels.

The CFIT 2 and 3 scales have parallel forms, namely form A and form B. Therefore, the 2 and 3 scales consist of 2A and 2B, while the 3rd scale consists of 3A and 3B. The CFIT scales 2 and 3 consist of four subtests. The four subtests are series, classification, matrices, and conditions or topology (R. Saptoto, 2018).

3. METHODS

A. Block of Research Diagram

In the research process, there are four stages of data processing. The four stages are Data Acquisition, Feature Extraction, Classification, and Evaluation. In this study, the tool used is Mindwave Mobile 2 which is used as a signal data acquisition tool. Then use the matlab r2017a software to perform the feature extraction process using the FFT algorithm. Then the classification process is carried out using the Convulation Neural Networks (CNN) algorithm.using python software. Then after the classification process is complete, an evaluation process is carried out using CNN to be able to determine the level of accuracy of a system. The four stages carried out in this research process can be seen in Figure 1 Research Method.

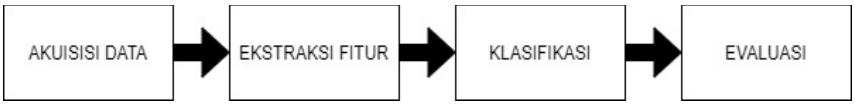

Figure 1. Research Method

B. Convolutional Neural Networks Architecture

Convolutional Neural Networks (CNN) consists of two layers, namely the feature layer and the classification layer as a detector/identifier (E. C. Djamal, W. I. Furi, and F. Nugraha, 2019). The CNN structure is divided into two main parts, namely Convolution Layers (CL) and Multilayer Perception (MP) (R. Widadi, B. A. Widodo, and D. Zulherman, 2020). CNNs have the potential to process data in the time domain, such as EEG signals. CNN consists of a convolution layer to extract features and a classification layer for learning (E. C. Djamal, R. I. Ramadhan, M. I. Mandasari, and D. Djajasasmita,

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2020). Figure 2 is the CNN architecture used (L. A. M. Pangistu and A. Azhari, 2021).

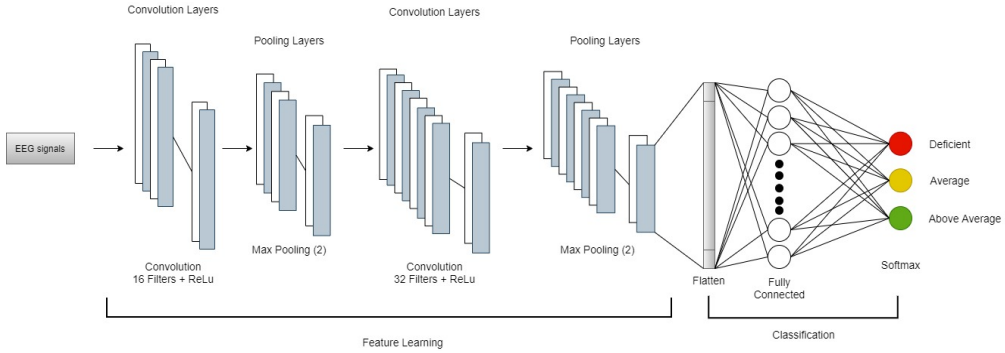

Figure 2. CNN Architecture

In the convolution layers there is a convolution process, which is where a kernel is multiplied and shifted on the input signal. This process is also known as the shift-compute procedure. The value obtained from the convolution process is still too high so it needs to be reduced. The reduction process is called polling. The most frequently used polling methods are max-polling and average polling. Max-polling is a method of taking the maximum value from a set of data, while in average-polling the value taken is the average value. After the polling process is complete, then the output of the process will be combined into 1 dimension, this stage is called flattening (R. Widadi, B. A. Widodo, and D. Zulherman, 2020).

Then, the next stage is the MLP process or *fully connected layer*. MLP consists of an input layer, a hidden layer and an output layer. The input layer receives input from the convolution layer stage and then sends the output to the hidden layer. Then the data class prediction will be shown by the output layer. Each layer has a number of neurons. Then the output of the neuron is entered into the activation function. The activation function used in MLP is ReLu (R. Widadi, B. A. Widodo, and D. Zulherman, 2020).

C. Data Acquisition

Data acquisition is a stage of taking a data which will then be used in a study. In this study, data acquisition using EEG tools by providing a stimulus to the respondents. Data collection in this study was carried out 2 times, namely at school and also at students' homes, with a span of seven days after data collection at school for 36 respondents who were willing to take their brain wave data using the CFIT and UK Mathematics tests and paired with the Neurosky Mindwave tool. Mobile 2 as an EEG recording tool when doing tests. The recording time using the EEG tool is 13 minutes for the CFIT test and 12 minutes for UK Mathematics.

D. Fast Fourier Transform

Fast Fourier Transform(FFT) is a very fast and efficient algorithm for calculating coefficients from Discrete Fourier Transform (DFT) to a finitesequence of complex data. The discrete fourier is a form of the signal time domain, while the finite is the signal domain that is converted from the signal time domain. The FFT algorithm is based on the basic principle of decomposition of DFT calculations from a sequence along N into successively smaller DFT transformations (O. Simanungkalit, R. Magdalena, and I. N. A. Ramatryana, 2018). One of the most frequently used forms for converting signals from the time domain to the frequency domain is the Fourier transform. Fourier transform can be defined by the formula:

$$S(f) = \int_{-\infty}^{\infty} s(t)\, e^{-j2\pi ft}\, dt \qquad (1)$$

Where :

S(f) : a signal in the frequency domain

S(t) : a signal in the time domain

And is a constant of the value of a signal, where the value of f is the frequency and the value of t is the time (R. Y. Sipasulta, A. S. M. Lumenta, and S. R. U. A. Sompie, 2014).

4. RESULTS AND DISCUSSION

A. Fast Fourier Transform and Normalization

Signal data retrieval is carried out in two stages, namely at school and at home. Furthermore, the EEG signal data that has been obtained is then carried out a feature extraction process to obtain the average peak value of each signal. Feature extraction is performed using the FFT algorithm. The FFT algorithm allows the processed EEG data to get the peak of each signal. After the signal peak is obtained, then the normalization process is carried out from 0-1. The lowest peak is zero and the highest peak is 1. The normalization process is carried out to obtain the average peak signal using Excel.

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Table 3. Examples of Minimum and Maximum Peak Data on Fast Fourier Transform

Number	FFT Peak Min UK	FFT Peak Max UK	FFT Peak Min CFIT	FFT Peak Max CFIT
Min	0.1553	0.0094	0.1876	0.0218
Max	5.5174	48.6209	4.8937	52.4434
Count	5.3622	48.6115	4.7062	52.4217

Table 4. Sample Data after Normalization

Normalization Peak Min UK	Normalization Peak Max UK	Normalization Peak Min CFIT	Normalization Peak Max CFIT
0.1826	0.0175	0.1915	0.01703

Table 5. Sample Data after Signal Cut

Normalization Peak Minimum UK	Normalization Peak Maximum UK	Normalization Peak Minimum CFIT	Normalization Peak Maximum CFIT
0.1826	0.0714	0.3622	0.1134

Table 6. Example of Final Data Extraction

Average Signal Maximum and Minimum UK	Average Signal Maximum and Minimum CFIT
0.1269	0.2378

B. Labelling

Labelling of each respondent is based on predetermined intervals.

Table 7. Categories of Assessment Results

Value Range	Information
0 - 59	Not enough
60 - 79	Average
80 - 100	Above average

C. Results

Based on the results of the recording of the EEG signal that has been processed with the FFT algorithm, the average obtained in the data collection process in schools by testing using CFIT and UK obtained the maximum signal mean value and minimum signal average value which can be seen in table 8 Results of the Average Test Signal Value in Schools. Then the average value of concentration on the subjects tested using CFIT and UK can be seen in Table 9 Results of the Average Concentration Signal Value in Schools. Average peak FFT in schools can be seen in Figure 3 Average Peak FFT in Schools. While the average obtained in the data collection process at home by testing using Mathematics and UK, the maximum signal average and minimum signal mean can be seen in Table 10 Results of the Average Test Signal Value at Home. Then the average value of concentration on the subjects tested using CFIT and UK Mathematics can be seen in Table 11 Results of the Average Concentration Signal Value at Home. Average peak FFT at home can be seen in Figure 4 Average Peak FFT at home.

Table 8. Results of the Mean Value of Testing Signals in Schools

Average	Maximum	Minimum
Average CFIT at School	0.3696	0.1176
Average UK at School	0.1835	0.0757

Table 9. Results of the Average Signal Concentration Score in Schools

Concentration	Average
Average Concentration in CFIT at school	0.2445
Average Concentration in UK at school	0.1330

Table 10. Results of the Average Test Signal at Home

Average	Maximum	Minimum
Average CFIT at Home	0.3256	0.1255
Average UK at Home	0.1859	0.0792

Table 11. Results of the Average Signal Concentration Value at Home

Concentration	Average
Average Concentration in CFIT at Home	0.2252
Average Concentration in UK at Home	0.1301

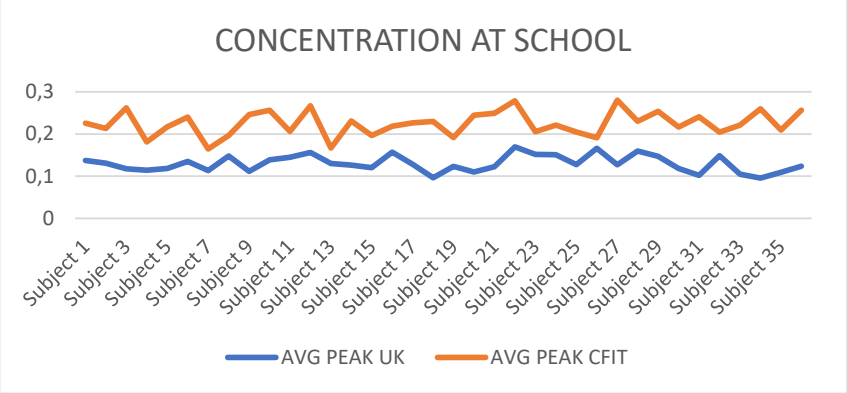

Figure 3. Average Peak FFT in School

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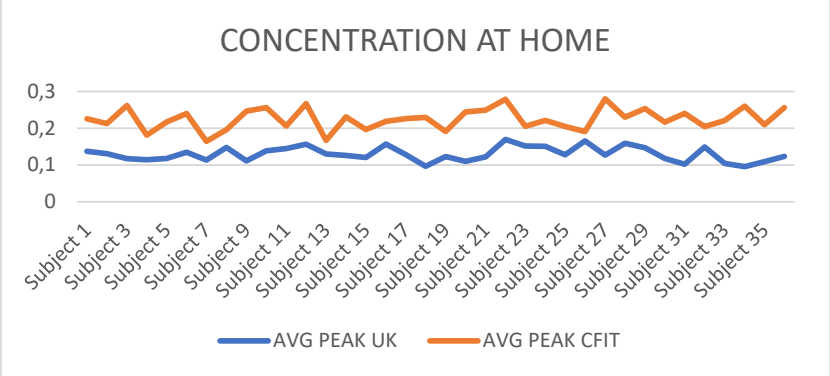

Figure 4. Average Peak FFT at Home

In the testing process carried out at school and at home, CFIT scores were obtained which can be seen in Table 12 CFIT Score at School and Table 13 CFIT Score at Home. Based on the results obtained in the testing process carried out at school and at home, the subject has a fairly low tendency for analytical skills so that this affects the subject's tendency to solve an existing problem. The CFIT score can be seen in Figure 5 CFIT Score at School and Figure 6 CFIT Score at Home.

Table 12. CFIT Score at School

Score	The highest score	Lowest Value	Average
CFIT Score	130	50	77.05

Table 13. CFIT Score at Home

Score	The highest score	Lowest Value	Average
CFIT Score	117	50	77.13

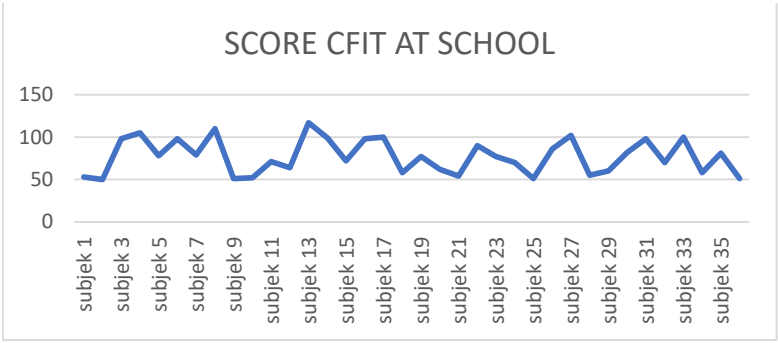

Figure 5. CFIT Score in School

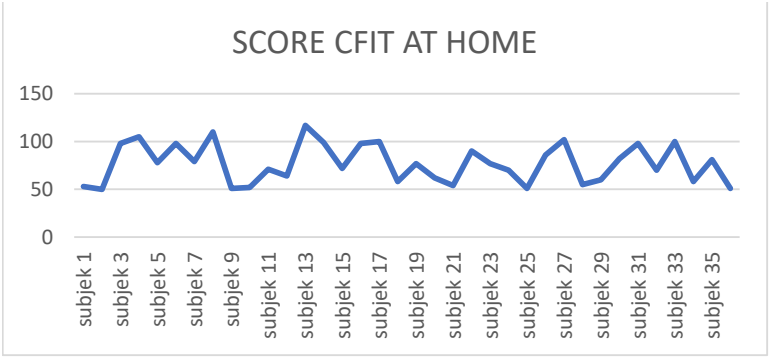

Figure 6. CFIT Score at Home

Then, in the testing process carried out at school and at home, UK scores were obtained which can be seen in Table 14 UK Score at school and Table 15 UK Score at home. The questions tested are 10 Mathematics questions with material obtained in even semesters to measure the subject's readiness to face PAS. Based on the results obtained in the testing process carried out at school and at home, the average UK score tends to be low. UK score can be seen in Figure 7 UK Score at School and UK Figure 8 score at Home.

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Table 14. UK score at school

Score	The highest score	Lowest Value	Average
UK Score	80	30	53.33

Table 15. UK score at home

Score	The highest score	Lowest Value	Average
CFIT Score	117	50	77.13

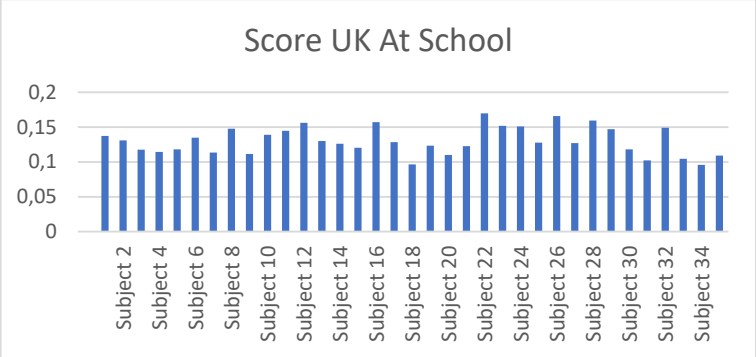

Figure 7. UK Score in School

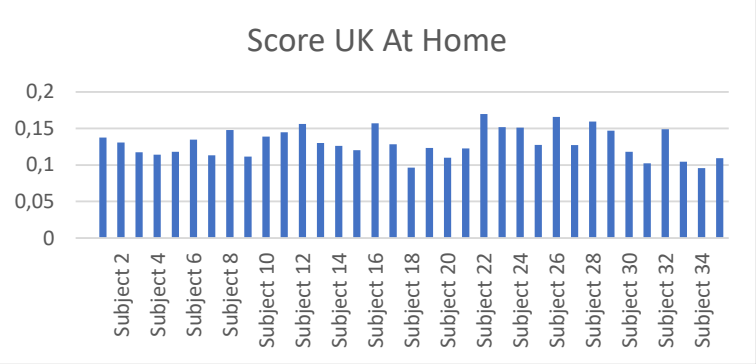

Figure 8. UK Score at Home

Based on 36 subjects that have been tested at school and at home, the average subject is in the first classification, namely Above Average as many as 12 subjects, then the average subject is in the second classification, namely Average as much as 12 subjects, and lastly the average subject is in the third classification, namely Less as many as 12 subjects. Thus, based on the classification that has been done, the subject has a low tendency to concentrate on a cognitive activity while studying at school or at home during the pandemic. The results of the classification can be seen in Figure 9 Classification Results at School and Figure 10 Classification Results at Home.

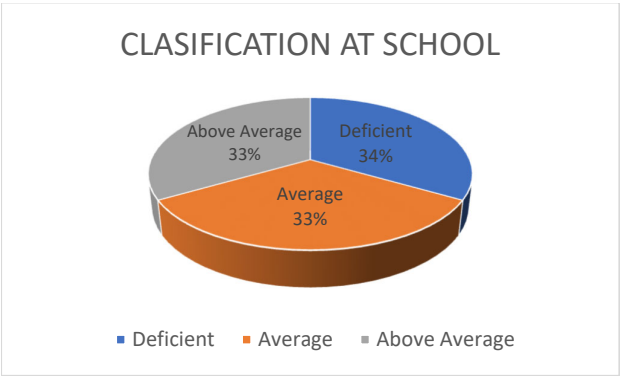

Figure 9. Classification Results in School

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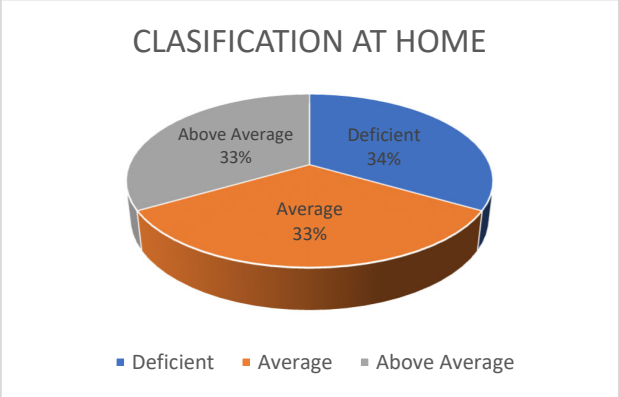
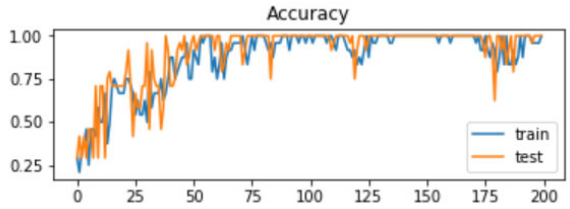


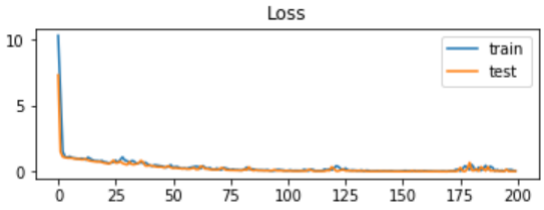
Figure 10. Classification Results at Home

D. Model Training and Testing Data

The data that has been processed previously consists of 3 classes (less, average, above average) and will be used as a dataset for CNN modeling that will be built. Then the data is divided into training data and test data with a ratio of 80:20, with 30 training data and 6 test data on testing data at school and at home. In this study, the CNN model used is 2 convolution layer processes and 2 pooling layers, each of which uses ReLu activity. From the data model training process at school, the accuracy value is 83.33% and in the data model training process at home, the accuracy value is 83.33%. Where the smaller the loss value obtained, the better the results. The results of the accuracy values in the training model process can be seen in Figure 11 (a) Train and Valdiation Accuracy, (b) Train and Validation Loss at School and Figure 12 (a) Train and Valdiation Accuracy, (b) Train and Validation Loss at Home

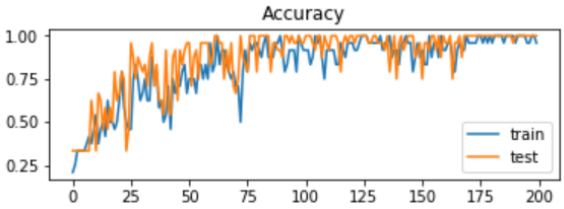


(a)



(b)

Figure 11. (a) Train and Validation Accuracy; (b) Train and Validation Loss at School



(a)

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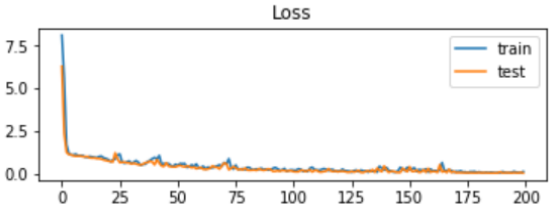

(b)

Figure 12. (a) Train and Validation Accuracy; (b) Train and Validation Loss at Home

5. CONCLUSIONS

Based on research that has been carried out on 36 subjects, the results of the recording of EEG signals that were tested at schools showed that the average signal concentration when testing using CFIT was 0.2445 and when testing using UK Mathematics was 0.1330 with an average CFIT score. of 77.05 and for the UK average of 53.33. Meanwhile, the results of the recording of the EEG signal that were tested at home showed that the average concentration of the signal at the time of testing using CFIT was 0.2252 and at the time of testing using UK Mathematics, it was 0.1301 with an average CFIT score of 77.13 and for the UK average of 57.50. So based on the results of the recorded EEG signal that has been obtained from tests carried out at school and at home, subject tends to have a fairly low level of concentration. Based on the results of interviews conducted with experts (psychologists), subjects who have low scores do not mean they are less intelligent. But there are several influencing factors. One of them is the existence of a pandemic that may weaken children's concentration power due to the lack of readiness of students to understand the material or it could be due to environmental factors during the online learning process that affect it. By using the CNN algorithm, the accuracy rate when testing at school is 83.33% and at home testing is 83.33%. Thus, no significant changes occurred in the concentration of students during the online learning process at home or at school during the pandemic.

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