



ANN Application: To Study Effect of Literacy and Numeracy Skills on Electrical Engineering Students' Performance

F. Zakaria^{1,a}, S.A.C. Kar^{1,b}, R. Abdullah^{1,c}, S.I. Ismail^{1,d}

¹Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Cawangan Terengganu, Dungun, 23000, MALAYSIA

Email: ^afathiahz@uitm.edu.my, ^bsitia2500@uitm.edu.my, ^crinaa5158@uitm.edu.my, ^dsyila5416@uitm.edu.my

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Abstract: In Higher Education level, literacy and numeracy skills is considered vital to the technical based courses and programs such as engineering. In fact, in universities' student intake selection process into engineering courses, results of mathematical subjects is highly considered. This study investigates the effect of literacy and numeracy skills of Diploma Electrical Engineering students' performance in Universiti Teknologi MARA (UiTM) Cawangan Terengganu, Kampus Dungun by using Artificial Neural Network (ANN). This research has been conducted on current final semester students (Semester 5). Three models of ANN are developed to observe the correlation between mathematical subjects and student performance which is measured by using Cumulative Grade Point Average (CGPA). The development of a model involves constructing several ANN designs and selecting network with the best performance. The historical data from students' database were used in the training and testing processes. The Regression Coefficient, (R) values from the developed models was observed and analyzed to see the effect of the mathematical subject to student performance. It can be proven that good literacy and numeracy skills in engineering students effect the student's performance.

Keywords: ANN Application, Literacy, Numeracy Skills, Electrical Engineering, Students

1. Introduction

Literacy and numeracy skills are crucial for accessing the broader curriculum as they are used in many aspects of our lives. Mathematics are integral parts of engineering which helps us to establish relationships among different quantities. From the elementary level, awareness of science, technology, engineering and mathematics (STEM) fields is included in school curriculum. As students pass on to the secondary level, they should study these subjects rigorously to prepare for engineering courses. Artificial Intelligence (AI), a field in computer science that involves the creation of intelligent systems that behave like human beings, has seen major development in the recent past. AI systems can be used to predict the future performance of a student by looking at their performance over time [1-3]. ANN is one of AI computational method that is suitable for this purpose [4-6]. In this study, ANN application is used to study the effect of the mathematical subjects to the performance of Diploma in Electrical Engineering student.

ANN is a simplified model of biological nervous system with highly interconnected network of a large number of processing elements called neurons. It mimics how human brain works process information. Recently, ANN becomes known as a powerful computational tool in diverse applications. ANN exhibits characteristic likes robustness, fault tolerance, high speed information processing, pattern association, mapping capabilities and great competence. Due to these unique characteristics, along with its ability to learn by example, it is intensely suitable for pattern recognition, classification, forecasting and solving unknown problems, including something new that is unknown by human expert [7].

ANN is a powerful technique which is very suitable for classification, pattern recognition and prediction tasks. Developing an ANN involved the process of finding optimal ANN architecture and parameters. However, there is no specific and systematic guideline available in designing ANN since it is an open concept design [8]. Data is the important elements that directly influence the quality of the developed ANN model. Data for training and testing process of ANN are obtained from students' database. The raw data are pre-processed to filter out irrelevant data and information which

may affect the ANN development process. In this study, ANN models are constructed by using MATLAB as the software is one of the flexible and efficient programming tools for ANN. ANN is categorized into two types of learning methods, supervised and unsupervised. In this study, supervised multilayer feed forward back-propagation is chosen as the network architecture because it is the most popular ANN architecture and applicable to this study scope of work. An important advantage of the network architecture is that it can learn directly from the training data and update knowledge when necessary [9]. In multilayer feed forward back-propagation networks, data moves only in one direction and error is propagated back to all nodes in previous layer [10]. Transfer function is also used in ANN to calculate output value of an ANN which is categorized into three types: linear, threshold and sigmoid. The syntax that represents the ANN configuration is given as:

Net = newff (P, T, S, TF, BTF, PF)
 where:
 P = Input
 T = Output
 S = Number of Neurons in Hidden Layer
 TF = Transfer Function
 BTF = Learning Technique
 PF = Performance Function

The ANN model development process involves the construction of several multilayer feed-forward back-propagation networks. Each network consists of input layer, hidden layer and output layer. In the training stage, processed data are used. Training stage is the most crucial process in designing the ANN model. ANN has the capability to learn from example and improve its performance through learning process. During training stage, the network is fed with data consisting of grade obtained by the students as the input and CGPA at semester 4 as the targeted output. Generally, training stage involves training data assembly, creation of network object, network training and simulation of the network response to the new inputs. The training stage will be discontinued after the ANN is fully trained. During training stage, the parameters of the network are varied heuristically to find the best network configuration.

During the testing stage, new data set is used to evaluate the trained ANN performance. In the testing stage, performance of the developed network is evaluated based on the value of correlation coefficient, *R*. *R* is computed to analyze correlation between network outputs and targeted output by measuring the strength and direction of a linear relationship of both [11]. A well trained network resulted in values of *R* close to 1, showing strong correlation between network output and targeted output. If the value of *R* is far from 1, re-training or re-design steps of ANN are required. The best network is then chosen based on *R* value that closest to 1.

2. Methodology

The overall research framework that reflects the breadth and depth of the study is shown in Figure 1. The study consists of three main stages which comprise of data collection and preprocessing, development of the 3 ANN models and results comparison of the models based on *R* value.

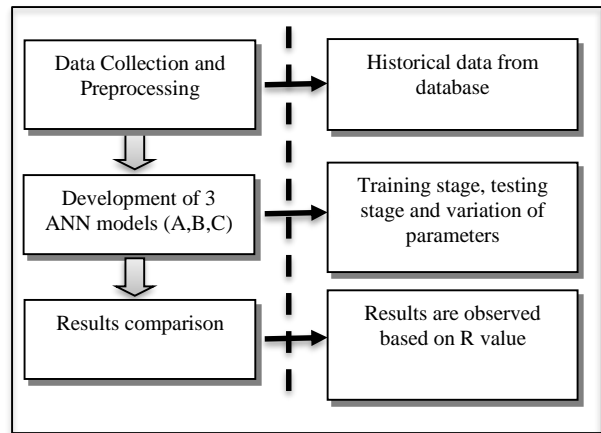


Figure 1: Research Framework

Three ANN models are developed (Model A, Model B and Model C). Table 1 tabulated the properties of input and the targeted output of the developed ANN models. The inputs consist of Grade Points of core subjects including Pre-Calculus (MAT133) and Calculus 1 (MAT183) taken by individual students at semester three. The targeted output of the ANN is the CGPA of the individual students at semester 4. Model A has four inputs: Pre-Calculus (MAT133), Calculus 1(MAT183), Electric Circuit 1(EEE121) and Electronics 1(ELE2320). Model B has two inputs: Electric Circuit 1(EEE121) and Electronics 1(ELE232) while Model C also has two inputs consist of Pre-Calculus (MAT133), Calculus 1(MAT183).

Table 1: Properties of Input and the Targeted Output

| ANN Model | Input Parameters | Output Parameters |
|-----------|--|-------------------|
| A | 1. Pre-Calculus (MAT133) 2. Calculus 1 (MAT183) 3. Electric Circuit 1 (EEE121) 4. Electronics1 (ELE232) | CGPA Semester 4 |
| B | 1. Electric Circuit 1(EEE121) 2. Electronics 1 (ELE232) | CGPA Semester 4 |
| C | 1. Pre-Calculus (MAT133) 2. Calculus 1 (MAT183) | CGPA Semester 4 |

The development of the ANN model involved determination of the ANN parameters such as learning technique (algorithm), number of neurons in hidden layer, Transfer Function (TF), Learning Rate (LR) and Momentum Constant(MC). These parameters are varied and determined heuristically in order to acquire a good ANN model. ANN architecture is the main structure of the ANN. In this study, three-layer ANN model that consists of one input layer, one hidden layer and one output layer is used. The learning technique used is Lavenberg-Marquart (LM) as it is a simple, robust and fast algorithm [12]. Early stopping technique is also applied in order to improve the developed model’s performance in term of generalization and to avoid overfitting.

The process of developing ANN models begins with the selection of parameters. The first stage is variation of neuron’s number and transfer function in hidden layer while the other parameters are kept fixed. Table 2 depicts the parameters involved in the variation process in order to select the ANN

model. The simulation involved variation of neuron's number and transfer function in the hidden layer.

Table 2: Properties of Input and the Targeted Output

| Parameters | Part 1 | Part 2 |
|-----------------------------------|---|---|
| Transfer Function | tansig | logsig |
| No of Neurons in Hidden layer | Varied from 20 to 2, decremented by step of 2 | Varied from 20 to 2, decremented by step of 2 |
| Transfer Function in Output Layer | purelin | purelin |

The simulation works can be divided into two parts: Part 1 and Part 2. For the first part, the number of neurons in hidden layer is varied from 20 to 2, decremented by the step of 2 and the transfer function used is tansig. The decrement step has been selected as 2 for the purpose of providing systematic variation of the hidden layer value since designing ANN does not have any systematic guideline and heuristic in nature. The transfer function is mathematical formula that determines the output of processing neurons [13-17]. The purpose of the transfer function is to prevent outputs from reaching very large values which can affect ANN model. The transfer functions in output layers are chosen to be 'purelin' since the output data lay down between 0 and 1. The transfer function in the output layers is kept fixed to see the effect of transfer function variation in the hidden layer. Second part, the number of neurons in hidden layer also varied from 20 to 2 similar to part 1 but the transfer function used is logsig. Both simulation works of Part 1 and Part 2 are done in order to see the effect of varying the number of neurons in hidden layer by using different transfer function, tansig and logsig. The next step is variation of the LR value.

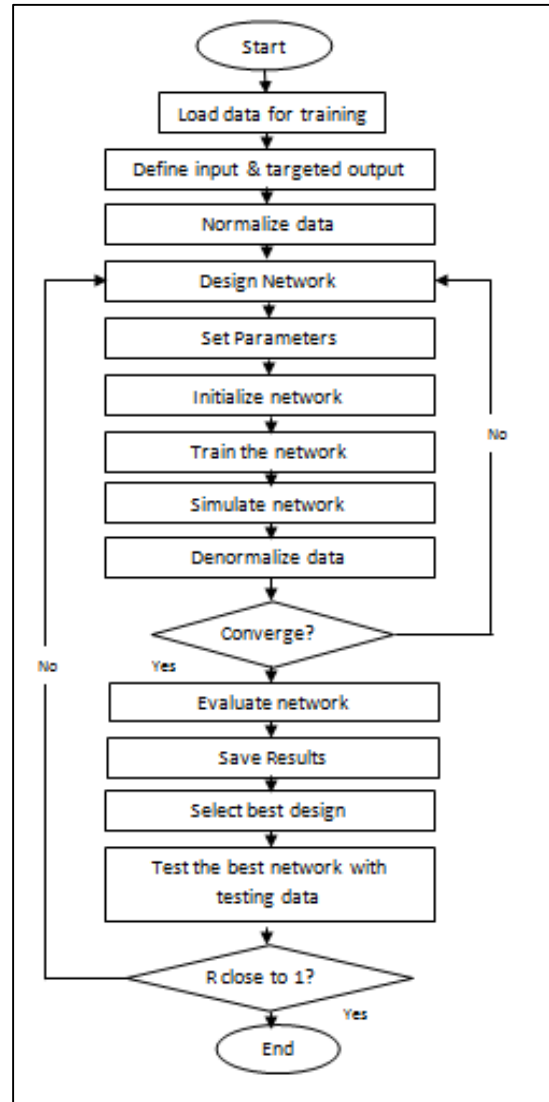
As mentioned previously, designing an ANN model does not have mathematical formulation, hence trial and error approach is applied. The LR value is varied from 0.02 to 1.00, incremented in steps of 0.02 to see the effect of LR variation towards the performance of the ANN models. This increment is considered acceptable interval for a maximum range of 1.00. The increment step has been selected as 0.02 for the purpose of providing systematic variation of the LR value since designing ANN is an open concept and involved heuristic method. There are 50 LR values used for the simulations. The last stage of ANN parameter selection process is variation the MC value on the best ANN model. Similar to LR, value of MC is varied from 0.01 to 1.00, incremented in steps of 0.02. There are 50 MC values used for the simulations. The same steps are applied to the three ANN Models (Model A, Model B and Model C). Figure 2 shows the general flowchart for an ANN model development which involves training and testing process.

3. Results and Discussion

Three ANN models were developed by using different set of inputs. 70% of data was used for training process and 30% was used for testing process. The correlation coefficient, R during testing process of the ANN models were observed. It is a best linear fit between targeted output(data) and real output from the ANN model. The R value from testing process shows how well the ANN models are learning from the training data. Figure 3, 4 and 5 illustrates the graph plot of the outputs versus targeted outputs of Model A, B and C respectively. Based on

the variation processes (i.e. heuristic technique), the selected ANN models with respective ANN parameters and values of R is summarized in Table 3.

Table 3 : ANN models with respective ANN parameters and values of R



From Table 3, it can be seen that the best (selected) R values obtained from the simulations for all models are having similar values. R for Model A (core subjects and English) is 0.89273, Model B (core subjects only) is 0.88373 and Model C (mathematical subjects) is 0.8999. The learning rate and momentum rate for each models are also shown in the Table 3.

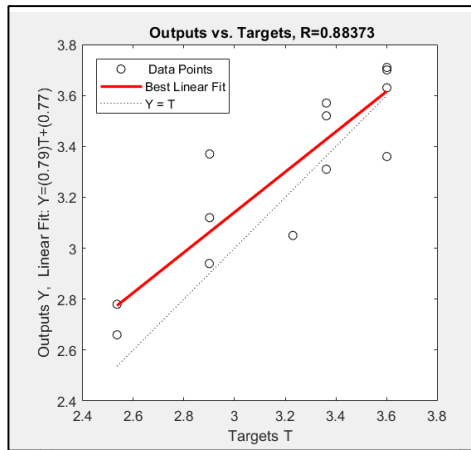


Figure 2: General Flowchart of ANN Model Development

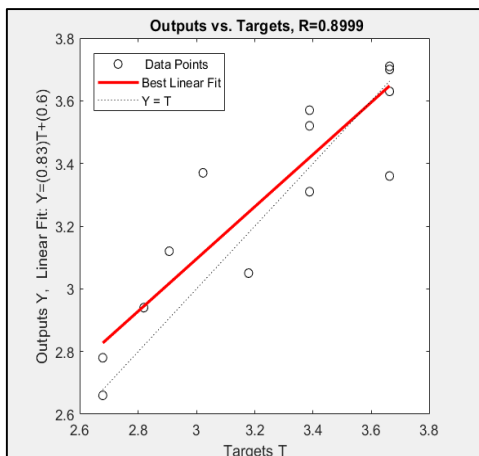


Figure 3: Correlation Coefficient, *R* of ANN Model A

Based on the *R* values obtained for Model C (0.8999) which has two mathematic subject inputs (MAT133, MAT183) has strong correlation with the output (CGPA). It can be concluded that literacy and numeracy skills has direct impact on the Diploma of Electrical Engineering students' performance.

Table 3: Properties of Developed ANN Models

| ANN Properties | Model A | Model B | Model C |
|----------------------------------|--------------------|--------------------|--------------------|
| ANN Configuration | [4 4 1] | [2 6 1] | [2 7 1] |
| Transfer Function | tansig | logsig | tansig |
| Learning Rate | 0.6 | 0.44 | 0.54 |
| Momentum Constant | 0.8 | 0.88 | 0.92 |
| Regression Coefficient, <i>R</i> | 0.89273 | 0.88373 | 0.8999 |
| Training Algorithm | Lavenberg-Marquart | Lavenberg-Marquart | Lavenberg-Marquart |

4. Conclusion

In a nutshell, this paper presents a study on impact of mathematic subject on electrical engineering students' performance by using ANN. The data was taken from students' database of Diploma students in Universiti Teknologi MARA

(UiTM) Cawangan Terengganu, Kampus Dungun. By using the developed ANN models, it can be concluded that students with strong fundamental in mathematic will give impact on their performance throughout the study years. This ANN models would be useful in helping the University management and faculty in planning a good strategy so that students' performance can be elevated. For future works, the process of designing ANN model (the parameter selection process) could be optimized by using another computational method such as Evolutionary Programming, Particle Swarm Optimization and etc. Study on the effect of core subject towards students' performance and possibility to be graduated on time also could be studied in near future. These kind of studies could give better overview and justification on issues happened in our higher educational system.

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