A Decision Support System for Predicting Students' Performance in the National Achievement Test (NAT) of Senior High School Students

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Abstract. Using data from the National Achievement Test (NAT) and student grades for senior high school students at Central Mindanao University, this study developed a Decision Support System (DSS). EDM, or educational data mining, must be completed prior to constructing the DSS. Support Vector Machine (SVM) with the Sigmoid kernel, the method used for EDM, achieved an overall accuracy of 96% with respect to the model. The model was then deployed in the DSS and saved. Leveraging Educational Data Mining and Machine Learning Techniques in Designing Strategic Interventions for Senior High School Students in CMU is a funded study that served as the basis for this study's inspiration.

Keywords: EDM · DSS · SVM

1 Introduction

These days, it is vital to evaluate students' performance. It can be applied to curriculum reviews, test difficulty evaluations, and learner knowledge assessments. Academic performance is a measure to determine pupils' progress in all academic courses, according to DepEd [22]. The typical criteria used by educators to evaluate student achievement are normative test scores, graduation rates, and classroom performance [22].

Teachers in the Philippines are overworked with paperwork [23, 24]. A teacher [23] is concerned about the deterioration in educational quality and learning loss. This implies that the teacher won't be paying close attention to assessing and monitoring the performance of the students.

Technology makes it possible to assess student achievement without putting in a lot of work. Regarding student performance, a Decision Support System (DSS) may be useful. The advent of the Decision Support System (DSS) may allow teachers to take a break while still having to assess their pupils' performance.

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In a reasonable length of time, a DSS can assist humans in making decisions. Certain analyses must be performed in order to design a decision support system. In addition, a substantial amount of data must be gathered and utilized.

Data mining will be the mode of analysis. The approach will be known as "educational data mining," and it will involve leveraging educational datasets. In this type of process, machine learning methods will be applied. The algorithm used in this study is the Support Vector Machine(SVM) with the Sigmoid Kernel. The algorithm's output will be referred to as a model, and it is employed in the deployment and development of the decision support system.

Students' grades and the National Achievement Test (NAT) dataset is used in this investigation. This study aims to create a Decision Support System for predicting National Achievement Test (NAT) performance based on the students' grades, which were gathered in advance in the study of Casildo [19] which was collected from Senior High School Students at Central Mindanao University.

1.1 Statement of the Problem

The primary issue with this study is that busy teachers failed to evaluate students' performance. A Decision Support System (DSS) might make the evaluation process easier for the teachers. This Decision Support System (DSS) will significantly reduce the amount of work that teachers must do. Furthermore, the Northern Mindanao Regional Development Policy Research Agenda.

2017–2022 Midterm Update states that the region's National Achievement Test (NAT) results indicate a worrying situation [18]. Students' NAT scores have been steadily declining over the preceding three years, placing them in the "poor mastery" or "low proficiency" description category [18]. The DSS will minimize the workload on teachers during the assessment process while also assisting in predicting student performance on the National Achievement Test (NAT).

The goal of this project is to create a digital tool that uses data mining techniques to forecast how well students will perform on the National Achievement Test (NAT) by creating a Decision Support System based on the students' grades.

1.2 Objectives

In general, the goal of this work is to create a decision support system that can predict students' results on the National Achievement Test (NAT) based on their grade. This type of decision support system seeks to enhance the quality of Basic Education, notably in Central Mindanao University Senior High School, if properly supported and implemented.

1.2.1 Specific Objectives

There are a few things the study must do initially in order to meet with its primary goal, and these are as follows:

- utilize the students grade and the NationalAchievement Test (NAT) dataset;

- apply pre-processing and transformation to the dataset;
- train and test the dataset using a data mining technique;
- evaluate the performance of the model;and
- save and deploy the model to a web application

2 Literature Review

2.1 Decision Support System (DSS)

The Decision Support System (DSS) application has advanced throughout time. The previous DSS-related studies [1–3] are all focused on theories of how it will influence decision-making. DSS is now utilized in a variety of domains, and numerous studies have shown its use in multidisciplinary methodologies. It is utilized in e-commerce [7], disaster management [4], psychological therapy [5], drinking water systems [6], and the prediction of heart disease [8]. The use of DSS is expanding and getting better in the field of education [9, 10, 11, and [12].

For students receiving scholarships, a decision support system for determining eligibility of recipients was developed [9]. Using the c4.5 function to produce a decision tree, this study employs data mining approaches to make predictions [9].

The achievement levels of specific program outcomes (PO) of students who have reached the graduation stage of any engineering degree have been generated using a decision support system based on a multi-criteria decision-making model [10]. The provision levels of POs were graded using a new method called MOORA (Multi-Objective Optimization on the Basis of Ratio Analysis), which was employed as a multi-criteria decision-making model in this work [10].

An additional study aims to develop a model to produce a tool that can identify the choices that must be made. The Multi-Criteria Decision Analysis (MCDA) method was used to create this model [11]. This strategy was chosen because it can be put into practice in a collaborative ecosystem with many stakeholders [11].

The AHP Algorithm was used in another excellent study being undertaken concerning selecting the top students in the classroom [12]. Based on the results of this study's data collection, it is possible to predict which students will be chosen as the best in their class [12].

2.2 Educational Data Mining

According to Romero & Ventura (2007), Educational data mining is an upcoming field related to several well-established areas of research including e-learning, adaptive hypermedia, intelligent tutoring systems, web mining, data mining, etc.

Educational data mining ensures a quality education by analyzing educational data based on various aspects [13]. Data mining is the process of transforming raw data into useful information [13]. The EDM process converts raw data coming from educational systems into useful information that could potentially have a great impact on educational research and practice [15].

Baker, R. S., & Yacef, K. (2009) classified work in educational data mining as Prediction (Classification, Regression, Density Estimation), Clustering, Relationship mining (Association rule mining, Correlation mining, Sequential pattern mining, Causal data mining), Distillation of data for human judgment, and Discovery with models [14].

2.3 DSS and EDM

A particular study [15] developed a decision support system (DSS) model for undergraduate student admission. Despite using a variety of data mining techniques, including k-Nearest Neighbors, artificial neural networks, and naive bayes, this study was unable to produce a decision support system [15]. Another study published [17] entitled "A Prototype A Prototype Decision Support System for Optimizing the Effectiveness of Elearning In Educational Institutions" is just a proposal and there is no certain decision support system being developed.Another study about Decision Support System of Scholarship Grantee Selection using Data Mining only focuses on the accuracy of the model and not to the developed decision support system and how will it be applied to the reality [9].

3 Methodology

The development of the model is the project's first phase. There are five (5) steps that need to be completed in order to construct the model. Data gathering, data preparation/cleaning, data mining, establishment of the algorithm for the decision support system, and finally, saving the trained model. These steps are shown in Fig. 1. The methodical approach taken in developing the model.

Figure 2 displays the deployment process. This procedure consists of three steps: using the trained model, loading the model, and converting it to a Decision Support System (DSS) web application.

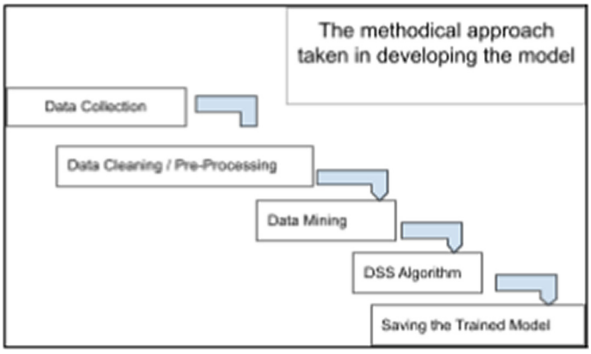

Fig. 1. The methodical approach taken in developing the model

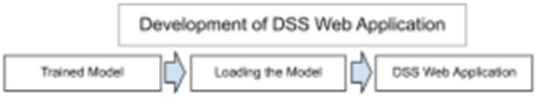

Fig. 2. Deployment Process

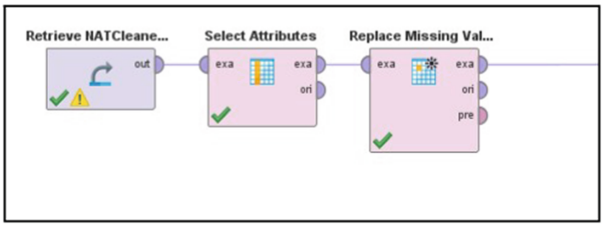

Fig. 3. Dataset cleaning using Rapidminer Software

3.1 Data Utilization

The study of Casildo [19], collected the dataset of this study. Prior to taking the National Achievement Test, periodic grades data on the student's subject performance grade in the school year 2017–2018 from a total of 723.

Senior High School students of Central Mindanao University [19]. Casildo [19], also assigned acronyms of the subjects.

3.2 Data Cleaning

Following data collection, data that had noises and inconsistencies was cleaned. If noise and inconsistent data are not neutralized, the result won't be accurate, which will lead to misunderstandings and inaccurate predictions. Figure 3 depicts how the data is cleaned using the rapidminer program. In RapidMiner, this procedure starts with retrieving the dataset, followed by the selection of the necessary attributes and the replacement of any missing values. All of these are operators in the application rapidminer.

The dataset was cleaned using the Rapidminer software. Three operators are utilized in this software: the Retrieve Operator, the Select Attributes, and the Replace Missing Values.In the Process, a RapidMiner Object is loaded using the Retrieve Operator.Then it was followed by the Select attribute operator which offers various filter types to make choosing an attribute simple.Then, lastly the replace missing values was used in this process of dataset cleaning. The attribute's minimum, maximum, or average value may be used to fill in any missing values. The missing values are replaced by the average by the average value of that attribute.

3.3 Data Mining

Please refer to the code (1) for the training and testing being used to determine the test size and train size for the Support Vector Machine (SVM) data mining approach that

was employed in this study.

```
X_train, X_test, Y_train, Y_test =
train_test_split(X, Y, test_size = 0.3,
stratify = Y, random_state = 2)
```
(1)

As shown in code (2) The shape function always produces a pair that contains the length of each dimension. The findings of empirical research showed that Support Vector Machine produced marginally superior performance [20].

```
print(X.shape,X_train.shape,X_test.shape)
classifier = svm.SVC(kernel='sigmoid')
classifier.fit(X_train,Y_train)
```
(2)

Kernel is utilized because the gateway to manipulating the data in Support Vector Machines is provided by a group of mathematical operations. The training set of data is typically transformed to enable a non-linear decision surface to transition to a linear equation in a larger number of dimension spaces. This study is using the classification approach. The Classification Model can be further extended for Posterior probabilities of SVM Classifiers, predictions and more accurate results by careful selection of values[21]. Using of SVM and Kernel can be seen in the code (2) above.

3.4 Evaluation of the Model

```
training_data_accuracy =
accuracy_score(X_train_prediction, Y_train)

X_test_prediction = classifier.predict(X_test)
test_data_accuracy =
accuracy_score(X_test_prediction, Y_test)
```
(3)

In the code above, (3) shows the code for evaluating the training set and the test set.

3.5 Saving the Model

```
filename = 'nat_datasets.sav'
pickle.dump(classifier,open(filename,'wb'))

loaded_model = pickle.load(open('nat_datasets.sav','rb'))
```
(4)

In acquiring the deployed model, .sav filename must be dumped in order to create a file. In code (4) shows the nat_datasets.sav as the file for the model. It will then be loaded into the Predictive System.

3.6 Deploying the Model

```
import numpy as np
import pickle
import streamlit as st
```
(5)

In deploying the model to the web based the first step is to import the libraries needed. These libraries are Numpy, Pickle and Streamlit. The Numpy is used for working with

arrays, Pickle is used to extract and save the model and the streamlit is used for the Deployment of the Decision Support System. In code (5) these libraries are being called.

```
loaded_model = pickle.load(open('D:/Machine
Learning/National Achievement Test/nat_datasets.sav','rb'))

def nat_prediction(input_data):


    # changing the input_data to numpy array
    input_data_as_numpy_array = np.asarray(input_data)

    # reshape the array as we are predicting for one
instance
    input_data_reshaped =
input_data_as_numpy_array.reshape(1,-1)

    prediction = loaded_model.predict(input_data_reshaped)
    print(prediction)

    if (prediction[0] == 0):
      return 'The person will get Very Low Mastery'
    else:
      return 'The person will get Low Mastery'
```

(6)

In code (6) the model is being loaded using the pickle library. It is assigned to the variable, loaded_model this model was being downloaded to the local machine, located in the local drive d.

```
def main():
```

(7)

In code (7) the def main() function is being created, this will be the main point of execution. Defining this main function is necessary to begin the program execution because it is only invoked when the program is started directly and not when it is imported as a module.

```
st.title('NAT Prediction Web App')

ELSG11Q1 = st.text_input('ELS-G11-Q1')
ELSG11Q2 = st.text_input('ELS-G11-Q2')
PSG11Q3Q3 = st.text_input('PS-G11-Q3')
PSG11Q4 = st.text_input('PS-G11-Q4 ')
PDG11Q1Q1 = st.text_input('PD-G11-Q1 value')
PDG11Q2 = st.text_input('PD-G11-Q2 value')
UCSPG11Q1 = st.text_input('UCSP-G11-Q1 value')
UCSPG11Q2 = st.text_input('UCSP-G11-Q2 value')
CLPWG12Q1 = st.text_input('2CLPWG12 Q1 value')
CLPWG12Q2 = st.text_input('2CLPWG12 Q2  value')
PHG12Q1 = st.text_input('PH-G12-Q1  value')
PHG12Q2 = st.text_input('PH-G12-Q2  value')
GMG11Q1 = st.text_input('GM-G11-Q1  value')
GMG11Q2 = st.text_input('GM-G11-Q2  value')
OCG11Q1 = st.text_input('OC-G11-Q1  value')
OCG11Q2 = st.text_input('OC-G11-Q2  value')
FG11Q1 = st.text_input('F-G11-Q1  value')
FG11Q2 = st.text_input('F-G11-Q2  value')
EAPPG11Q1 = st.text_input('EAPP-G11-Q1  value')
EAPPG11Q2 = st.text_input('EAPP-G11-Q2  value')
RWSG11Q3 = st.text_input('RWS-G11-Q3  value')
RWSG11Q4 = st.text_input('RWS-G11-Q4  value')
FG11Q3 = st.text_input('F-G11-Q3  value')
FG11Q4 = st.text_input('F-G11-Q4  value')
ICTG11Q3 = st.text_input('ICT-G11-Q3  value')
ICTG11Q4 = st.text_input('ICT-G11-Q4  value')
MILG12Q1 = st.text_input('MIL-G12-Q1  value')
MILG12Q2 = st.text_input('MIL-G12-Q2  value')
ArtsG12Q1 = st.text_input('Arts-G12-Q1  value')
ArtsG12Q2 = st.text_input('Arts-G12-Q2  value')
```

(8)

Inside the main function is the code in (8), this part assigns the input in the variables. In this case, the subjects are the variables.

4 Results and Discussion

The major goal of this work is to create a decision support system that can predict, depending on a student's grade, how well they would perform on the National Achievement Test (NAT). By following the methodology's phases, this study has developed a

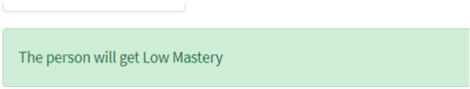

Fig. 4. Result Notification

system that can f orecast test results for the National vement Test (NAT) based on students' s. Figure 5 depicts the outcome of the opment and is titled NAT Prediction Web Each textbox has a question about the in a certain subject, and when the button d "Student NAT Result" is clicked, the sis of the Data Mining Techniques that mployed will be applied to determine utcome that is displayed. Figure 4 ys a sample result notification.

Achie grade devel App. Grade labele analy were e the o display.

This study made use of the Casildo [19] dataset that was gathered. Prior to using the data mining technique, the dataset was cleaned. Figure 6 depicts an example uncleaned dataset with additional characters and missing values. Figure 7 displays an example cleaned dataset in which no missing values or noise were present.

The data mining method for this study used Sigmoid and Support Vector Machine (SVM). The test set's accuracy score is 96%, whereas the training set's accuracy score is 95%. The overall accuracy rating of the model is 96%.

The classification report for the model with sigmoid kernel is displayed in Fig. 8. Only the values Low Mastery and Very Low Mastery are included in the data values from the national achievement test in Casildo's pre-dataset assessment [19]. In this study, the values 0 for Low Mastery and 1 for Very Low Mastery are assigned. The percentage of relevant occurrences among the recovered examples is known as precision, also known as positive predictive value. It responds to the query, "What percentage of affirmative identifications was actually correct?". The precision report of Low Mastery is 94% and the Very Low Mastery is 100%.

Recall, which is often referred to as the sensitivity, hit rate, or true positive rate (TPR), is the percentage of all relevant instances that were actually retrieved. What percentage of real positives were correctly identified, then?". The recall value for Low Mastery is 100% and for Very Low Mastery its 93%.

The proportional mean of precision and recall, or the F1 score, is a measurement of a test's accuracy. It has a range of 0 to 1 (perfect recall and precision), with 1 being the highest possible result. It evaluates how accurate and reliable your model is all in all. F1-Score is .97 for both Low Mastery and Very Low Mastery.

Support is the number of instances of the class that actually occur in the dataset. It only diagnoses the performance evaluation procedure and does not differ between models. Support is 15% for both Low Mastery and Very Low Mastery.

Since Google Colab was used to generate the model, it was stored using the .sav filename and was then extracted. Figure 9 depicts the extracted model as a file with the filename nat datasets.sav.

Fig. 5. The National Achievement Test (NAT) Prediction Web App

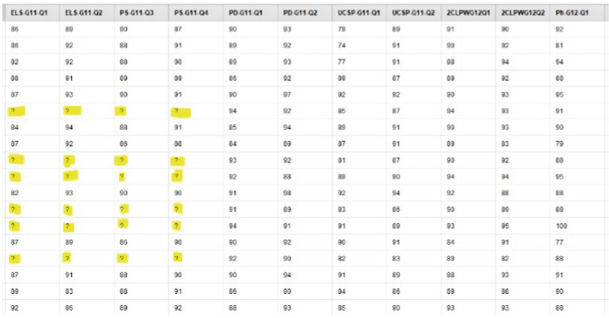

Fig. 6. Uncleaned Dataset

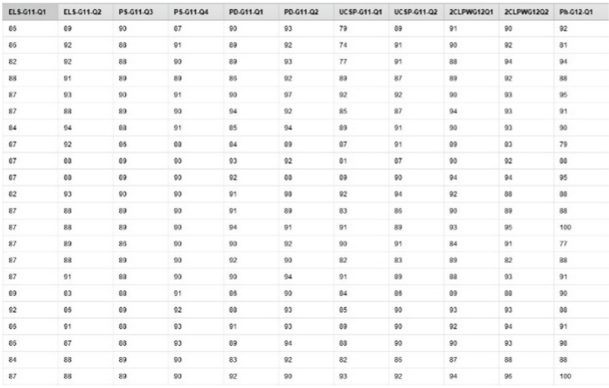

Fig. 7. Cleaned Dataset

```
Classification Report of the model with sigmoid kernal:
              precision    recall  f1-score   support

           0       0.94      1.00      0.97        15
           1       1.00      0.93      0.97        15

    accuracy                           0.97        30
   macro avg       0.97      0.97      0.97        30
weighted avg       0.97      0.97      0.97        30


Accuracy: 0.9666666666666667
```

Fig. 8. Classification report of the model with sigmoid kernel

Fig. 9. nat_datasets.sav

5 Conclusion

It became feasible and highly probable to develop a decision support system utilizing a machine learning model. This study has demonstrated the extent to which educational data mining and decision support systems can be beneficial. It will be very beneficial in assessing and evaluating students' performance in a variety of subjects and fields, not simply the National Achievement Test (NAT). If the data is gathered in real-time, this type of system will be very helpful to teachers in the evaluation of learners. This might be an evolution in how teachers assess their students.

6 Recommendations

There are a few suggestions that have come out of this study that will assist this kind of study be improved. The first issue is that there aren't many datasets being gathered; more datasets would be useful. Furthermore, because the dataset is only exclusive to a certain semester at Central Mindanao University and a small number of students, the analysis and model will not be very helpful for students in other batches or types. If evaluating the performance of the student per region is the primary objective, collecting and utilising additional datasets will be necessary. In order to discover differences, it is advisable to use another type of algorithm rather than Support Vector Machine (SVM), which will result in less overfitting. The second recommendation is the use of oversampling functions or other strategies that will help in overcoming overfitting.

Finally, although Feature Selection was not employed in this study, it may be useful to do so in the future to choose just subjects that are significantly related to the National Achievement Test and to identify the relationships between various subjects.

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