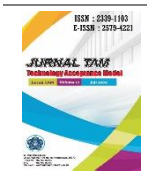

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THE NAÏVE BAYES METHOD AS A MEASUREMENT MODEL EFFECTIVENESS OF ONLINE LEARNING

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Abstract
The rapid development of technology requires the world of education to be able to take advantage of its positive impact, making various new innovations by utilizing technology to support education such as online learning in the learning process amid the Covid-19 pandemic. Changes in learning methods which occur suddenly from conventional learning methods or directly face-to-face switching to distance learning methods or using online learning media greatly impact and influence students who come from underprivileged families and students who are in remote areas where internet access and inadequate infrastructure. This study aims to create a classification model for measuring the effectiveness of online learning in Pringsewu using the classification method. The classification method is used to classify data based on the nature of the data which each class already recognizes. There are various methods which can be used to classify data using the Naïve Bayes method. The results of the research conducted are a classification for measuring the effectiveness of online learning in Pringsewu. The feasibility of the model obtained is supported by the results of the analysis of the Naïve Bayes model which has an accuracy rate of 98.48%, an AUC value of 0.995, a precision level of 98.17% and a 100% recall. In this study, the level of accuracy of the performance of the model used reached values above 90%. In addition, the AUC value of the two methods used is also more than 90% which is a value that is categorized as Excellent Classification. Further research can be carried out using other different parameters such as Economic Capability, Regional Location, Connectivity Mode, Digital Literacy, and others. In addition, this research was conducted only from the student's point of view. Inclusion of school opinion in future research will be useful in determining the exact effectiveness of online learning.

I. INTRODUCTION

Human life is inseparable from the influence of technological developments which continue to increase. The rapid development of technology has an influence on human lifestyle, both positively and negatively. Humans as users of technology must be able to take advantage of the positive impact of technological developments in several aspects of life such as work, social and education. Technological developments in the educational aspect of course

provide so many conveniences such as in terms of teaching and learning which can be done by online. The use of technological developments in education is supported by the increasing use of the internet every year. Based on APJII survey data in 2022, internet use in Indonesia reached 210 million.

Research by Vaibhav Gallani (2020), [1] research showed that of the total respondents, the majority (97.65%) know online learning platforms because several platforms are explored by the government with various initiatives. The results of the analysis show that the reasons for not attending lectures regularly have nothing to do with data consumption, costs, indiscipline, faculties, etc. Feeling lethargic is a major determinant of students not attending online lectures. This is because most students agree that online teaching cannot be considered as a substitute for offline teaching. Research by I Made Setiawan, et al (2021), [2] the implementation of Undiksha E-Learning during the Covid-19 pandemic in the Physical Education and Health Study Program was classified as effective. This is supported by the percentage of student concentration paying attention to the lecturer's explanation of 96%, understanding of learning material 88%, motivation in participating in online learning with Undiksha E-Learning by 77%, and student learning outcomes classified as 88% and has implications for the continued use of e- learning Undiksha as a platform used by lecturers and students in learning. Research by Muhammad Syamsudin Sofie, et al (2022), [3] research showed that online learning media has a positive impact on the teaching and learning process. There was an increase in student GPA after the implementation of online learning media during the Covid-19 pandemic. This also shows that learning interactions can run optimally if there are learning managers (teachers), learning, learning resources, subjects, and interactions. Students rated online media learning as very effective (23.3%), effective (46.7%), and average (20%). However, some students believe that online learning is inefficient.

Based on research that has been done previously, it shows that online learning platforms are effectively used and there is no relationship between data consumption, costs, indiscipline, faculties, etc. In addition, other studies also show that the implementation of e-learning is effectively used as an online learning medium during the Covid-19 period which is supported by an increase in student GPA. However, in other studies, learning outcomes using online media are classified as effective but not efficient. The research conducted measures the effectiveness of online learning using the Naïve Bayes algorithm by using several variables to find out whether learning using online media is effectively implemented and can have sustainable implications as one of the learning media.

II. THEORETICAL BASE

A. Data Mining Concept

According to Kusrini (2009), [4][5]–[7] The terms data mining and knowledge discovery in database are often used interchangeably to describe the process of extracting hidden information in a large database. The understanding of these two terms has different concepts, but they are related to one another. One of the stages in the entire process of knowledge discovery in databases is data mining. Knowledge discovery in the database can be broadly explained in Figure 1.

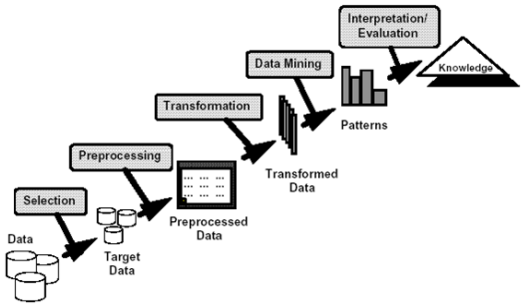

Figure 1. Stages of Knowledge Discovery in Database

Stages of Knowledge Discovery in Database:

1. Data Selection
   Data selection is a selection of a set of operational data which is carried out prior to the Knowledge Data Discovery information extraction stage. Furthermore, the data are stored in a separate file from the operational database.
2. Preprocessing or Cleaning
   Preprocessing or Cleaning is a process for removing data duplication, checking for inconsistent data, and correcting data errors.
3. Transformation
   Transformation is a data transformation process which has been selected for the data mining process.
4. Data Mining
   Data mining is the process of looking for patterns and interesting information from selected data using certain methods.
5. Interpretation or Evaluation
   Interpretation or evaluation is a pattern of information obtained from the data mining process which is displayed in a form which is understood by interested parties.

B. Naïve Bayes

Naïve Bayes is a classification algorithm which is quite simple and easy to implement so that this algorithm is very effective when tested with the correct data set, especially if Naïve Bayes is combined with function selection, so Naïve Bayes can reduce redundancies in data. In addition, Naïve Bayes shows good results when combined with the

clustering method. Naïve Bayes is proven to have high accuracy compared to support vector machines. [8][9].

Bayesian classification is a statistical classification which can be used to predict the probability of membership in a class discovered by British scientist Thomas Bayes. Bayesian classification is based on the Bayes Theorem which has the ability to predict future opportunities based on previous experiences known as the Bayes Theorem. Bayesian classification is proven to have high accuracy and speed when applied to databases with large data [10][11], [12].

The calculation of Naïve Bayes uses equation 1.

$$P(H|X) = \frac{P(H|X)P(H)}{P(X)} \quad (1)$$

Information:

X = Data with unknown class (proof)
H = Data hypothesis X is a specification class
P (H|X) = Probability of hypothesis H is true for condition X
P (H) = Probability of hypothesis H
PX = Prior probability of proof X

C. Validity and Reliability Test

A research must test the research instrument first before conducting data analysis. Testing research instrument data can be done using validity and reliability tests. In this study, the authors used validity and reliability tests to measure the validity and reliability of the criteria which will be used to measure the effectiveness of online learning.

Validity Test (Bivariate Person – Product Moment)

According to (Sugiyono, 2016:168), valid means that the measuring instrument used to obtain (measure) data is appropriate. The validity of the measuring instrument is tested by calculating the correlation between the values obtained from each statement item and the total obtained on the measuring instrument. The product moment correlation formula can be seen in equation 2.

$$r_{ix} = \frac{n\sum ix - (\sum i)(\sum x)}{\sqrt{[n\sum i^2 - (i)^2][n\sum x^2 - (\sum x)^2]}} \quad (2)$$

Where:

r_{ix} = item correlation coefficient – total (bivariate person)
i = item score
r = total score
n = the number of subjects that took the test

Bivariate Person (Product Moment) test criteria

a. If r count > r table (2-sided test with a significance of 0.05), then the instrument or statement items correlate significantly with the total score (**declared valid**).
b. If r count <r table (2-sided test with a significance of 0.05), then the instrument or statement items do not correlate significantly with the total score (**declared invalid**).

Reliability Test (*Cronbach's alpha*)

Reliability means constancy. A measurement instrument can be said to be reliable if the instrument can be used repeatedly and gives the same measurement results. The instrument reliability test was carried out to determine the consistency of the measuring instrument, whether the measuring instrument used remained consistent when used repeatedly. The Alpha formula (*Cronbach*) can be seen in equation 3.

$$r_{ac} = \left[\frac{k}{k-1}\right]\left[1 - \frac{\sum \sigma b^2}{\sigma_{t^2}}\right] \quad (3)$$

Where:

r_{ac} = instrument Reliability
k = the number of questions
$\sum \sigma b^2$ = the number of variants
σ_{t^2} = Total variant

Alpha Assessment Criteria (*Cronbach*)

The significance test was carried out at a significance level of 0.05, meaning that the instrument can be said to be reliable if the alpha value is greater than the r critical product moment.

III. RESEARCH METHODS

A. Method of collecting data

The data collection method is an important thing in research and is a strategy or method used by researchers in collecting the data needed in their research. Data collection methods used in this study are:

Questionnaire

A questionnaire is a collection of written questions and usually involves a large number of people. Questionnaires can be done in writing (paper based) or electronically. Usually a sample is chosen to represent a particular population (Hanif Al Fatta, 2007: 70). Based on the above understanding, in this study the authors use an electronic questionnaire (*Google form*) closed.

Field Study

Observation or direct observation is a technique or way of collecting data by observing ongoing activities [13]. The data collection technique was carried out during field studies, by collecting data directly on High School/ Vocational High School students of the same level.

Data Collection Techniques

In this study, probability sampling was used as a sampling technique. The use of this technique was chosen because each element of the population used

has the same probability of being selected as the sample. The sample is the population that is taken in part to be used as an object in research. According to Arikunto (1986: 107) if the number of subjects is less than 100, then it is better to use all subjects so that the research is a type of population research. Furthermore, if the number of subjects is more than 100, 10% - 15% or 20% - 25% can be taken (Ekaresta Prihardjati Saputro, 2018). In the research which the authors conducted at High School/ Vocational High School in Pringsewu District, the authors took a sample of 20% of 66 High School/ Vocational High School in Pringsewu District.

B. Research Flow

This research was carried out by applying Naive Bayes to measure the effectiveness of online learning. The flow of the research stages created as a framework for measuring the effectiveness of online learning is the development of the research model being carried out [14], or can be seen as shown in Figure 2.

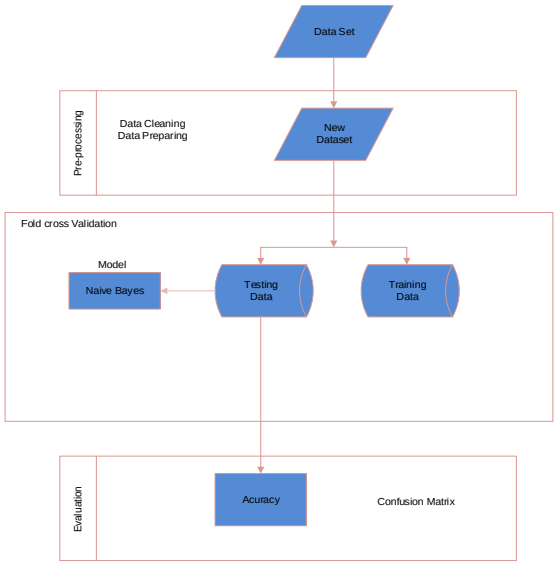

Figure 2. Research Flow Process

IV. RESULTS AND DISCUSSION

A. Results

The data used in the classification process was obtained from the data collection process through an online questionnaire (Google form) and a printed questionnaire (questionnaire). The data processed in this discussion is the response data for High School/ Vocational High School students of the same level in Pringsewu Regency for 2020/2021 which were taken through an online questionnaire (*Google form*) and a printed questionnaire.

The data used in the validity and reliability tests are data from questionnaires distributed using online media (*Google form*) and printed questionnaires, where the questionnaires were distributed to 17 High School/ Vocational High School in Pringsewu Regency with a total of 125 questionnaires distributed. Of the 125 questionnaires distributed, only 120 questionnaires were collected, while the other 5 questionnaires received no response. Of the 125 questionnaires collected, 64 of them were obtained from online questionnaires (*Google form*) and 61 questionnaires were obtained from printed questionnaires. Of the 120 questionnaires collected, only 109 could be processed, while the 11 questionnaires were error questionnaires.

Validity and reliability tests were carried out to test the validity and reliability of an instrument used in research. In this study, the authors used validity (Bivariate Person – Product Moment) and reliability (*Alpha – Cronbach*) tests to measure the validity and reliability of the criteria which are used to measure the effectiveness of online learning.

Table 1. Variables

No	Criteria	Information
1	Internet access	Internet Access Speed
2	Network Infrastructure	Network Infrastructure Availability
3	Instructional Media	The media used in the online learning process
4	Gadget Network	Network which can be accessed by devices used in the learning process
5	Mastery in the operation of technology	Ability to operate digital devices
6	ICT Infrastructure	School Technology Capability
7	Learning	Learning concept

Validity test

$$r_{xy} = \frac{n\sum XY - (\sum X)(\sum Y)}{\sqrt{[n\sum X^2 - (\sum X)^2][n\sum Y^2 - (\sum Y)^2]}}$$

$$r_{xy} = \frac{109(21184) - (492)(4623)}{\sqrt{[109(2286) - (492)^2][109(199859) - (4623)^2]}}$$

$$r_{xy} = \frac{2309056 - 2274516}{\sqrt{[24917 - 242064][21784631 - 21372129]}}$$

$$r_{xy} = \frac{34540}{\sqrt{[7110][412502]}}$$

$$r_{xy} = \frac{34540}{\sqrt{2932889220}}$$

$$r_{xy} = \frac{34540}{541561559} = 0{,}6378$$

Table 2. Instrument Validity Test Results

No	Criteria	r Count	r Table	Information
1	Internet access	0.63	0.176	Valid
2	Network Infrastructure	0.65	0.176	Valid
3	Instructional Media	0.64	0.176	Valid

4	Gadget Network	0.65	0.176	Valid
5	Mastery in the operation of technology	0.56	0.176	Valid
6	ICT Infrastructure	0.57	0.176	Valid
7	Learning	0.55	0.176	Valid

Reliability Test

$$r_{ac} = \left\lfloor \frac{k}{k-1} \right\rfloor \left[1 - \frac{\sum \sigma b^2}{\sigma_{t^2}} \right]$$

$$r_{ac} = \left\lfloor \frac{7}{7-1} \right\rfloor \left[1 - \frac{5.614849}{14.31991} \right]$$

$$r_{ac} = \lfloor 1.1667 \rfloor \lceil 0.607899202 \rceil$$

$$r_{ac} = 0.709215735$$

Table 3. Reliability Test Results

No	Criteria	r ac	Information
1	Internet access	0.709	Reliable
2	Network Infrastructure		
3	Instructional Media		
4	Gadget Network		
5	Mastery in the operation of technology		
6	ICT Infrastructure		
7	Learning		

B. Discussion

After conducting validity and reliability tests, 7 (seven) valid and reliable criteria are obtained to be used in this study. These criteria are internet access, network infrastructure, learning media, learning concepts, device networks, mastery in operating technology, and ICT infrastructure owned by schools. Apart from the 7 (seven) criteria, there are two (2) additional criteria. Those are motivation in learning and understanding of learning material referred to previous research conducted by Purwaamijaya [15] where the criteria of motivation in learning and understanding of learning material have been tested for validity and reliability in previous studies.

Table 4. Merging Variables

No	Criteria	r ac	Information
1	Internet access	0.709	Reliable
2	Network Infrastructure		
3	Instructional Media		
4	Gadget Network		
5	Mastery in the operation of technology		
6	ICT Infrastructure		
7	Learning		
8	Motivation in learning		
9	Understanding Material in learning		

The second data collection process was carried out using 9 variables through the *Google form* and distributing printed questionnaires and as many as 670 data were obtained that would be used to test the effectiveness of online learning.

1. Data Selection
   The second data retrieval is then made into a data set in the raw data for the pre-processing process.
2. Pre-Processing
   Before the data mining process can be carried out, it is necessary to carry out a cleaning process on the data to remove duplicate data. The total amount of data obtained from distributing questionnaires is 670 data. 147 of them were obtained from the *Google form* and 523 other data were obtained from the distribution of printed questionnaires. After the data pre-processing is done, there are 659 data that can be processed while the other 11 data are error data.
3. Transformation
   In this process, the Rapid Miners application is used as a tool to create a data mining process. The following is an illustration of the application of the Naive Bayes model using a rapid miner as shown in Figure 3.

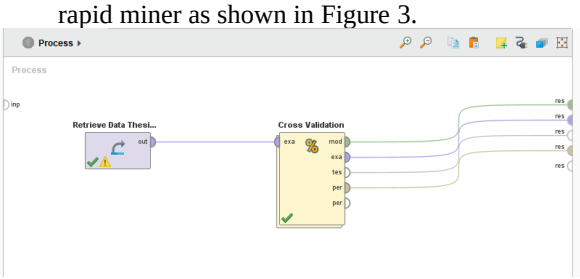

Figure 3. Data Import

The import process using Rapid Miner is used to describe or predict opportunities based on each condition. In this process, the Rapid Miners application is used as a tool to create data mining processes. The following is an illustration of the application of the Naive Bayes model using Rapid Miner as shown in Figure 5.

4. Data Mining
   The classification process using the Naive Bayes model is used to describe or predict opportunities based on each condition. In this process, the Rapid Miners application is used as a tool to create data mining processes. The following is an illustration of the application of the Naive Bayes model using the rapid miner as shown in the image. After the target label process is shown in Figure 4, it can then be seen as shown in Figure 4 below.

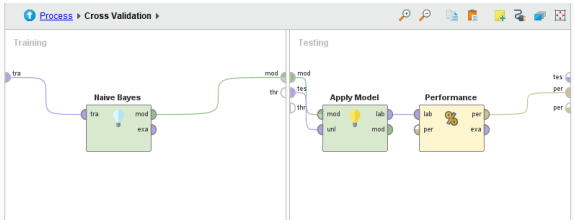

Figure 4. Naïve Bayes scheme

Figure 4 is the process of forming a Naive Bayes scheme where at that stage a Naive Bayes model is selected to test the input data.

5. Interpretation

Based on Figure 4 which has been built on the rapid miner application, the results are obtained as shown in Figure 5.

Attribute	Parameter	Tercapai	Tidak Tercapai
Kecepatan Akses Internet yang dimiliki	value=Tinggi	0.205	0.017
Kecepatan Akses Internet yang dimiliki	value=Sedang	0.795	0.818
Kecepatan Akses Internet yang dimiliki	value=Rendah	0.000	0.165
Kecepatan Akses Internet yang dimiliki	value=unknown	0.000	0.000
Infrastruktur Jaringan yang dimiliki wilayah	value=Tinggi	1.000	0.835
Infrastruktur Jaringan yang dimiliki wilayah	value=Rendah	0.000	0.165
Infrastruktur Jaringan yang dimiliki wilayah	value=unknown	0.000	0.000
Jaringan yang dapat diakses Gawai/ Smartphone	value=Rendah	0.008	0.013
Jaringan yang dapat diakses Gawai/ Smartphone	value=Tinggi	0.992	0.987
Jaringan yang dapat diakses Gawai/ Smartphone	value=unknown	0.000	0.000
Media Pembelajaran	value=Tinggi	0.538	0.044
Media Pembelajaran	value=Sedang	0.462	0.956
Media Pembelajaran	value=unknown	0.000	0.000
Konsep Pembelajaran	value=Tinggi	0.856	0.402
Konsep Pembelajaran	value=Sedang	0.144	0.598

Figure 5. Naïve Bayes Test Results

Figure 5 is a distribution table of test results from the Naive Bayes model. The table describes predictions based on the parameters of each variable. In addition to the distribution table as shown in Figure 5, the results of testing the data using the Naive Bayes model also obtain accuracy results as shown in Figure 6.

accuracy: 98.48% +/- 1.60% (micro average: 98.48%)

	true Tercapai	true Tidak Tercapai	class precision
pred. Tercapai	122	0	100.00%
pred. Tidak Tercapai	10	527	98.14%
class recall	92.42%	100.00%	

Figure 6. Naïve Bayes Accuracy Results

From Figure 6, it can be seen that the data testing carried out using the Naive Bayes model has a fairly high accuracy rate of 98.48%. This shows that the classification process is good. The amount of data which was predicted to be achieved and actually achieved was 122, and the amount of data which was predicted to be achieved and actually not achieved was 0. The amount of data which was predicted was not achieved and actually achieved was 10, and the amount of data predicted was not achieved and actually not achieved was 527.

An overview of the Simple Distribution of the Naïve Bayes method can be seen in Figure 7 below.

SimpleDistribution

```
Distribution model for label attribute Nilai Hasil Evaluasi


Class Tercapai (0.200)
9 distributions

Class Tidak Tercapai (0.800)
9 distributions
```

Figure 7. Naïve Bayes Simple Distribution

The results of the classification of online learning data tested using Naïve Bayes can be seen based on Figure 4.20 where from the online learning data there are two labels " ACHIEVED or NOT ACHIEVED". The label "ACHIEVED" indicates the class "EFFECTIVE" with a value of 0.200 and the label "NOT ACHIEVED" indicates the class "NOT EFFECTIVE" with a value of 0.800.

C. ROC Analysis

The Naïve Bayes ROC curve shown in Figure 8 shows the visualization of the AUC 0.995 results, which are included in the Excellent Classification category. In Figure 8, it can be seen that there are 2 curves, the blue and red curves. Based on the picture, the blue line is better than the red line. This is because the blue line crosses through the point 0.0, while the blue line crosses close to 0.1.

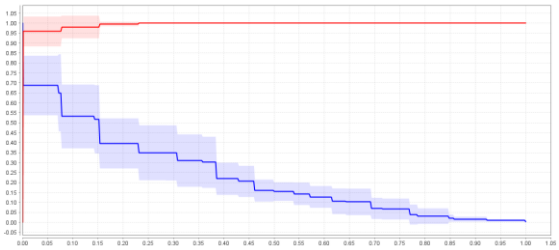

Figure 8. ROC

V. CONCLUSION

Based on the discussion which has been described about measuring the effectiveness of online learning using Naive Bayes on data from High School/ Vocational High School students of the same level, it can be concluded that the model or function describes the class of effectiveness of online learning using several criteria. The speed of internet access, network infrastructure owned by the region, networks which can be accessed by devices, learning media, learning concepts, motivation in online learning, understanding of learning materials, mastery of technology operations, and ICT infrastructure illustrate the level of effectiveness of online learning in Pringsewu District which is still far away of achievement or can be said to be ineffective. From several criteria which are used as the basis of the measurement then processed using Rapid Miner to build a measurement model that is described using

a decision tree. The feasibility of the model obtained is supported by the level of accuracy and class precision obtained. The accuracy level of the Naive Bayes algorithm is 98.48% and the Naïve Bayes ROC shown in Figure 10 shows the visualization of the AUC 0.995 results which are included in the Excellent Classification category.

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