

## Multiple Intelligences and Reading Comprehension of Senior High School Students: A Response Evaluation through Educational Data Mining Technique



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### ABSTRACT

This study predicts the accurateness of the students' responses in the actual evaluation conducted in San Jose, District of Dinagat Islands, Philippines, in determining the Multiple Intelligences (MI) and Reading Comprehension in Literature of the Senior High School students as basis for an intervention program. In this paper, the prediction which is one of the optimal techniques in data mining was observed to test the accurateness of the responses as perceived by the 319 senior high school students. The use of the Naïve Bayes algorithm depicted a 79.93% accuracy when applied in the evaluation dataset when performed using the 10-folds cross-validation scheme in WEKA software. The high accuracy percentage denotes that the actual study is worthy of implementation. It is hoped that the study will contribute to the two major kinds of literature; data mining and in higher education mining.

**Keywords:** Data mining, educational data mining, multiple intelligences, naïve bayes, reading comprehension,

### 1. INTRODUCTION

Reading Comprehension is the ability to process information that has been read and then understand its meaning. Reading skill is essential equipment for teachers' knowledge, experiences, and abilities. It helps people develop their thinking and quality of life too. It is one of those crucial language skills that a person should acquire. Like any other skill, reading must be practiced continuously to be able to become well-versed [1].

The importance of reading is to build the ability and knowledge of students. There are setS of learning goals that must be achieved by the students; the ability to read a wide range of texts in English, the ability to adapt the reading style according to the reading purpose, the ability to build knowledge of the English language, the ability to construct schematic knowledge, the ability to develop an awareness of the structure of written texts in English, and the ability to take or assume a critical perspective concerning the contents of the texts [2].

Poor reading can be treated through explicit and systematic instruction to address specific underlying weaknesses such as phonological awareness, phonological memory, word attack skills, vowel patterns, common word parts and patterns, syllabification strategies, and linguistic retrieval [3]. Although there are many studies made, most of it focused on the primary and secondary level's problems of reading comprehension.

However, in the District of San Jose, Province of Dinagat Islands, Philippines, reading comprehension among the Senior High School students is somehow a problem. Many students have a poor analysis of literature and even reading worksheets. It is, therefore, necessary for the teachers to provide as many opportunities as possible to enhance and teach students the skills or strategies needed to improve their reading comprehension [4]. Teachers should develop teaching methods to deliver effective instruction to develop students' reading abilities. A recommended theory accepted to improve reading is the application of multiple intelligences into teaching [5].

Based on the previous statements, actual research was conducted to investigate if multiple intelligences (MI) significantly relate to the reading comprehension of the students. The quest to improve their reading skills and provide a set of reading worksheets that will meet their specific potentials and needs was undertaken [6].

Despite the advent of technology, there are still many researchers who used the old predefined queries and charts in conducting research. With the use of researcher-made questionnaires, the responses on these evaluations are tallied and are kept in databases while interpretation is drawn using statistics and basic mathematical methods. The use of traditional qualitative and quantitative research methods often unlikely to accomplish a well-established knowledge extraction from databases. These methods are outdated and the use of the latter limits the researchers in achieving their quality objectives. With the advent of technology, a new paradigm called data mining (DM) has emerged [7].

Data mining, also called Knowledge Discovery from Databases (KDD) extracts implicit information or knowledge from databases using data mining and machine learning algorithms. Some of the well-known functions in data mining used diverse approaches of DM analysis, such as Bayes classifiers, clustering methods, neural networks, optimization algorithms, support vector machines, regressions, prediction and many more [8], [9]. These approaches encourage data analysis in its full potential with the help of the right algorithms. Among the many data mining approaches, the prediction is considered as the prime method that is commonly used in educational data mining, business, health, and even in almost all sectors of the society [10].

Therefore, this study used the widely renowned Naïve Bayes algorithm to predict the accuracy and evaluate the responses used in the study of [6]. The result of this study will serve as a basis in the development of an improved intervention program and will be added to the literature of data mining particularly the application of Naïve Bayes algorithm.

## 2. LITERATURE REVIEW

### 2.1 Reading Comprehension

Reading is fundamental to all learning, both in learning in general and in acquisition of languages. The ability to read involves more than merely decoding a text. In addition to the practical skill of putting letters together, turning them into words, one is also supposed to understand what is read: one has to combine decoding; the ability to put words together, with comprehension; the result of interpreting linguistic elements [11].

However, it is common knowledge, as well, that many of our secondary students in public schools can read but can hardly comprehend English texts even if they are already in their secondary or tertiary level. Thus, reading strategies instruction is directed towards teaching learners a repertoire of reading strategies that will allow them to develop a sense of conscious control of their cognitive processes [3].

Comprehension is highly interactive, such that readers use a variety of skills and processes when encountering text. These processes are complex and consist of multiple components. A variety of cognitive models have been developed to lend support to the various skills and processes thought to impact comprehension [12]. Therefore, it is not only important to read and interpret the text, but it is also essential to interpret visual clues and master nuances of subtext, all while following at times ideas in a non-linear way as the text is read [13].

In senior high schools, the students are usually given a textbook with various reading texts to help them improve their reading ability. They are expected to comprehend the texts. However, there are still some senior high school students who still have difficulties in understanding the texts. During the writer's experience in classrooms, students often made mistakes in reading. It was found that some of the students do not comprehend the texts. When they independently answer some questions related to the text, the students like to copy the answers from the texts, using the same sentences. If there are questions that are implicitly stated in the text, the students often give wrong answers. Based on these cases, it can be said that their reading comprehension is low.

According to [16], the student must first engage in tasks of literal comprehension before engaging in more in-depth interactions with the text, such as those prompted by inferential and evaluative understanding. More specifically, literal comprehension tasks require readers to retrieve information that has been explicitly stated in a passage. Inferential comprehension tasks require readers to understand relationships that may not be explicitly stated in the passage but are essential for passage understanding, such as the connection between two events in a narrative or understanding a character's motive for a particular action. Evaluative comprehension tasks require readers to analyze and critically interpret the text based on their prior knowledge and experiences. This taxonomy is prepared to determine the status of students' reading comprehension [14].

### 2.2 Multiple Intelligences

The multiple intelligences (MI) theory was developed by

Howard Gardner. According to [17], Gardner developed the Multiple Intelligences as an alternative theory to traditional understandings of intelligence and IQ testing. Assuming that assessing an individual's intellectual potential is complicated and that areas of expertise or skill will be valued differently based on their societal and cultural context, Gardner proposes that an IQ exam does not adequately assess an individual.

Gardner defined intelligence as producing valuable products in culture and characterized it as potential biopsychology helping to process data, which can be activated in a cultural context to solve problems [18]. Each person has an individual intelligence profile, consisting of different capacities that are related to all the nine bits of intelligence. This intelligence constitutes how individuals process information. Besides, Multiple Intelligence theory supports the idea of existence of several intelligences that result in a unique cognitive profile for each person [19].

There are eight multiple intelligences that Gardner proposes, namely: Verbal-Linguistic, Logical-Mathematical, Visual-Spatial, Bodily-Kinesthetic, Musical, Interpersonal, Intrapersonal and Naturalistic.

#### A. Verbal/Linguistic Intelligence

It refers to the ability to use words and language. The learners have highly developed auditory skills and are generally good speakers. They think in words rather than pictures [20]. This indicates that some students may master telling stories, but not writing. Others may learn answering numerical mathematical questions, but not verbal ones.

#### B. Logical/Mathematical Intelligence

This intelligence includes sensitivity to logical patterns and relationships, statements, and propositions [5]. It is the ability to use numbers and reason well, explore relationships, such as cause and effect, make connections, and use experiments to examine things [21].

#### C. Visual/Spatial Intelligence

This intelligence possessed artistic capabilities, have an eye for detail and color, spatial awareness, and enjoy painting and sculpting [22]. They can also visualize things and learn through movies easily [21].

#### D. Bodily/Kinesthetic Intelligence

It is a deep understanding of what one can craft, communicate, or alter using the hands and body. This includes acts of athleticism and physicality, including balance, woodworking, and spearfishing, as well as expressions of ideas and feelings such as dance or acting [17].

#### E. Musical Intelligence

It involves the ability to understand pitch, rhythm, and tone as well as thinking in sound. Being able to manipulate music and combine its elements is a portion of musical intelligence. Many people with Musical intelligences can often hear and remember sounds that others might miss [18].

## F. Interpersonal Intelligence

It is the ability to perceive and make distinctions and feelings. This includes sensitivity to facial expressions, voices, and the ability to respond effectively to those cues in some pragmatic way [5].

## G. Intrapersonal Intelligence

This kind of ability is self-smart. Individuals with this intelligence learn best when they are given time to process information and reflect on their learning [22].

These intelligences give students to demonstrate their knowledge formally, considering the theory of Howard Gardner on assessment. Assessment opportunities should engage students' areas of strength. While traditional measures address linguistic and logical-mathematical skills, an overreliance upon assessments that cater to these skills favors students strong in these areas [23].

Schools like Key Learning Community that emphasize a multiple intelligences approach may "soon become a legacy of historical importance in the field of innovative public education, rather than a legacy that serves hundreds of students daily in ways that prepare students to make important contributions in our world" [24]. Thus, an ideal multiple intelligences instruction, rich experiences, and collaboration provides a context for students to become aware of their intelligence profiles, to develop self-regulation, and to participate more actively in their own learning" [25].

The implementation of MI theory coupled with increased parental involvement, can lead to substantial gains in the learners' reading comprehension and vocabulary knowledge [26]. Thus, testing approaches that capture the diverse types of intelligence with a focus on individuals rather than the average student can account for the various intellectual capabilities of children in a classroom [23].

## H. Naturalistic Intelligence

Naturalistic intelligence, according to [27] is a skill to identify and classify various species including flora and fauna, in an environment.

## 2.3 Data Mining Techniques

Premised in the application of data mining in all areas in research, this trend is undoubtedly inevitable. DM is a medium of discovering novel and potentially valuable information from large amounts of data [28]. The field of Educational Data Mining (EDM) is new and developing in the area of education sector [29]. This emerging field concerns with developing methods that discover knowledge from data from educational environments. Data mining techniques such as decision trees, Naïve Bayes, K-Nearest Neighbor, neural networks, K-means clustering, and many others, are instrumental in extracting data from the datasets [30] used for classification, clustering, and prediction, among others. A study of [9] predicted the accuracy of the instructional performance employed by the faculty in SUC's in the Caraga Region, Philippines. Two data mining technique namely the prediction and clustering were used

revealing an 87% prediction accuracy using the K-means-C4.5 prediction model.

The use of data mining techniques has attracted more and more attention in this big data era [31]. Prediction, as one of the data mining techniques, can be made utilizing autoregressive integrated moving average (ARIMA) algorithm that used historical data in predicting cases extent in education, society, climate, health, and others. The ARIMA model was also used in forecasting dengue hemorrhagic fever cases in Southern Thailand [32]. Further, the use of the ARIMA algorithm in the prediction of travel time to the urban roadway was also discovered [33]. The Philippines' electric consumption [34] and inflation prediction [35] were also realized by the use of the ARIMA algorithm. Furthermore, the same algorithm has been used in forecasting incidence of hemorrhagic fever with renal syndrome in China [36].

Extent of crime analysis, the data mining techniques were implemented to understand specific trends and patterns of terrorist attacks in India. K-means clustering was used to determine the year wherein the terrorist groups were most active and also which terrorist group has affected the most [37]. Further, an attempt to predict the index and non-index crimes in Surigao del Norte, Philippines was done using the K-Means clustering algorithm and ARIMA algorithm. Predicting crime occurrence for the years 2018-2022 was achieved based on the historical crime data from years 2013-2017 [38]. Another study analyzed crimes such as theft, homicide, and various drug offenses along with suspicious activities, noise complaints, and burglar alarm by using qualitative and quantitative approaches [39]. The rates of each crime and the cities with high crime rates have been identified using K-means clustering data mining approach applied in crime datasets from the New South Wales region of Australia.

## 3. METHODOLOGY

### 3.1 Datasets

The dataset used in the study are the responses of the 319 senior high school students from Don Ruben E. Ecleo Sr. Memorial National High School (DREESMNHS), Don Jose Ecleo Memorial Foundation College of Science and Technology (DJEMFCST), and Cuarenta National High School (CNHS) located at the Province of Dinagat Islands, Philippines. Table 1 shows the profile of the respondents in the experimental group in terms of their age, sex, school, and track. The dataset that will be used are the tallied responses of the students from the 64-item test questionnaire deployed. The accuracy of responses answered by the students is validated and tested using Naïve Bayes Algorithm. This is to prove the effectiveness and the accurateness of the responses of the student-respondents.

**Table 1:** Profile of the respondents

	Profile	F (n=319)	Percent
Age	14-17	155	48.6
	18-19	141	44.2
	20 and above	23	7.2
Sex	Male	131	41.1
	Female	188	58.9

School	DREESMNHS	251	78.7
	CNHS	11	3.4
	DJEMFCST	57	17.9
Track	Academic	261	81.8
	TVL	58	18.2

It can be gleaned from the Table that there are 155 or 48.6% out of the 319 respondents who are 14-17 years old, 141 or 44.2% who are 18-19 years old, and 23 or 7.2% who are at least 20 years old. There are 131 or 41.1% who are male and 188 or 58.9% who are female. They are distributed into three schools: 251 or 78.7% are from DREESMNHS, 11 or 3.4% from CNHS and 57 or 17.9% from DJEMFCST. As to track, there are 261 or 81.8% enrolled in academic track and 58 or 18.2% are taking TVL.

### 3.2 Naïve Bayes (NB) Algorithm

The Naïve Bayes classifier is a probabilistic classifier based on Bayes’ theorem. Its attributes are fully independent [40], making it reliable and simple to use. Some of the notable advantages of the NB Algorithm includes simplicity to execute and its ability to cope up with noise and irrelevant data. The complete formula of the NB algorithm is found in the study of [41].

### 3.3 Prediction Evaluation Tools

Countless forecasting and prediction models found in the literature are evaluated using the various forecast error statistical tools. The use of accuracy, precision, recall, and F-measure, mean absolute error (MAE), and root mean squared error (RMSE), respectively, conformed to the formula as derived from the study of [34] as to wit:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \tag{1}$$

$$P = \frac{TP}{TP + FP} \tag{2}$$

$$R = \frac{TP}{TP + FN} \tag{3}$$

$$F - measure = 2 \times \frac{precision \times recall}{precision + recall} \tag{4}$$

$$MAE = \sum_{i=T+1}^{T+h} | \hat{y}_i - \bar{y}_i | / h \tag{5}$$

$$RMSE = \sqrt{\sum_{i=T+1}^{T+h} (\hat{y}_i - \bar{y}_i)^2 / h} \tag{6}$$

where TP, TN, FP, and FN mean true positive, true negative, false positive and false negative, respectively. The lower the statistical error value is, the better the forecasting ability of the model.

## 4. RESULT AND DISCUSSION

The use of the Waikato Environment for Knowledge Analysis (WEKA) software was instrumental to the training and testing of datasets using the Naïve Bayes algorithm. To test the predictive capability of the NB algorithm, the dataset was simulated using the 10-folds cross-validation scheme. The prediction model obtained a prediction accuracy of 79% making the responses of the students in the study of [6] reliable and worthy of implementation as shown in Tables 2-3. The precision of the dataset is optimal with an overall score of 82.7%. This denotes that 82.7% of the dataset are correctly classified by the algorithm when used in WEKA.

Further, the recall metric denotes that 79.9% of the instances in the dataset were retrieved by the system correctly and revealed an excellent performance. The f-measure showed an 81.1% balance performance of the model. Lastly, the RMSE and MAE showed a zero-based value of 0.4003 and 0.235, respectively revealing how concentrated the prediction is. A low value for RMSE and MAE depicts a good forecast.

**Table 2:** Prediction model accuracy evaluation

Model	Accuracy %	Precision	Recall	F-Measure
Naïve Bayes	79.9373 %	0.827	0.799	0.811

**Table 3:** Forecast error evaluation

RMSE	MAE
0.4003	0.235

## 5. CONCLUSION

Predicting the accuracy of the students’ responses in the study conducted by [6] is essential since it will be used as the basis in intensifying the reading program of the schools in the Province of Dinagat Islands, Philippines to help improve the reading comprehension in literature of the senior high school students according to their multiple intelligences.

Since it is not enough that research is conducted using predefined methods, the use of the data mining technique, particularly the prediction of the accurateness of the responses like in the study of [42] were undertaken. The simulation result showed the effectiveness of data mining technique particularly the use of NB algorithm in knowledge extraction and validation. The use of the algorithm in predicting the accurateness of the responses helped the researcher in validating the acceptability level of the knowledge acquired when the predefined methods were used prior to its implementation. It is recommended that the output of this study be used in data proliferation and influence administrator’s decision.

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