ISSN 2278-3091
Volume 9, No.1, January – February 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse107912020.pdf
https://doi.org/10.30534/ijatcse/2020/107912020

Students Performance in Board Examination Analysis using Naïve Bayes and C4.5 Algorithms

Edison L. Polinar[1*], Allemar Jhone P. Delima[2], Ramcis N. Vilchez[3]
[1, 2]Professional Schools, University of Mindanao, Matina, Davao City, Davao del Sur, Philippines
[3]College of Computing Education, University of Mindanao, Matina, Davao City, Davao del Sur, Philippines
[1]edisonpolinar@umindanao.edu.ph, [2]allemardelima@umindanao.edu.ph, [3]ramcis_vilchez@umindanao.edu.ph

ABSTRACT

In this generation, where the educational system is being added with new policies and requirements, the higher education institutes (HEIs) use data mining tools and methods for scholastic improvement of student performance. The authors gathered information from the Bachelor of Secondary Education (BSEd) graduates of Davao del Norte State College (DNSC), thru the Institute of Education (IEd) and other offices concerned. The information is comprised of six (6) attributes for analysis that are as follows: stanine, general weighted average (GWA), honors received, the type of scholarship that the specified respondents have, review center admission, and Licensure Examination for Teachers (LET) remarks. After the tools were performed on the datasets, it is found out that the general weighted average (GWA) is the most influential with the attribute's value of 0.171 and followed by review center admission with the attribute's value of 0.132. The performance of the models Naïve Bayes and C4.5 in predicting the students' performance in the Licensure Examination for Teachers were compared in terms of accuracy to identify which among the two classification algorithms performs best. Results show that Naïve Bayes has 85.14% and 90% prediction accuracy using both 10-fold cross-validation and 70% training and 30% testing, while C4.5 accumulated 86.13% and 86.66% accuracy for 10-fold cross-validation and 70-30 percentage split, respectively. Using Naive Bayes algorithm, the AUC results to 0.8507 and 0.8333 when using the C4.5 algorithm. Therefore, it is construed that Naive Bayes results are more consistent, suitable and reliable when testing the data compared to C4.5. Recommendations cited in this study as to expanding the precision of the prediction of student performance in future.

Key words: Academic Performance, Educational Data Mining, Licensure Examination for Teachers (LET)

1. INTRODUCTION

As the saying goes, teachers are regarded as "heroes"; and is deemed as one of the noblest professions. Furthermore, it is labelled as a fulfilling job since teachers are given the responsibility to mold their students' soul, body, and mind inside the classroom [1].

Given the effects of teachers on students and the students' effects on technology, economic, social and political development in the future, a requirement to pass the Licensure Examination for Teachers (LET) has been imposed to aspiring teachers to regulate the teaching practice. Hence, the Philippine Teachers Professionalization Act of 1994 was circulated-- mandating that "All applicants for registration as professional teachers shall be required to undergo a written examination which shall be given at least once a year in such places and dates as the Board may determine upon approval by the Commission. A valid certificate of registration and a valid professional license from the Commission are required before any person is allowed to practice as a professional teacher in the Philippines, except as otherwise allowed under this Act." (R.A. 7836, Art III Sec. 13) [2], [3].

Passing the Licensure Examination for Teachers (LET) creates an impact on the school, and one of its objectives is to let the students pass the examinations [3]. Also, the schools should create platforms that will guide teachers in reflecting on their teaching practices and behavior. Such a platform to be implemented will allow them to improve their teaching practices and personality as teachers. However, one of the simplest ways to assess teaching competency is to evaluate the results of the graduates' performance in licensure examination [1].

During enrolment, every educational institution acquires useful data from the students. And to make use of the data, data mining has been materialized. Data mining or also known as Knowledge Discovery in Database (KDD) refer to extricating or "mining" knowledge from the vast amount of data being collected [4], [5].

Data mining is composed of a different group of techniques. It can be used to extract pertinent and fascinating data from the historical data [6], [7]. Data mining in education is termed Educational Data Mining (EDM). EDM, as outlined by the International Academic Data Processing Society, is "an emerging discipline, concerned with developing methods for exploring the unique types of

data that come from educational settings, and using those methods to better understand students, and the settings which they learn in" and a powerful tool for academic intervention [8], [9].

Data will be collected from numerous academic institutes that reside in their respective databases. The information will be personal or educational which may be utilized to perceive student behaviour, judge and improve e-learning systems, enhance curriculums and teaching, help instructors, and other more plenty of alternative advantages can be furthered [10], [11].

The Professional Regulation Commission (PRC), on December 1, 2019, released the results of the September 2019 Licensure Examination for Teachers (LET), also known as *Teachers Board Exam*. Davao del Norte State College (DNSC) is one of the top-performing schools in the September 2019 Licensure Examination for Teachers as per Commission Resolution No. 2017-1058 (C) series of 2017 with a total number of 140 examinees. The college has produced a total number of 119 passers with one (1) top 4 students, two (2) top 9 students, and one (1) top 10 students. Having these results, DNSC ranked nine at the secondary level. And at present, instructors and students from the said institute are faced by the challenge of maintaining DNSC's LET performance.

Thus, this study aims to predict the performance of the school's students in the Licensure Examination for Teachers (LET) by extracting knowledge discovery from the student database to advance student performance. Distinguishing the predictors of the students' LET performance is essential information that can contribute to the institution's establishment of policies and development of instructional methods to improve and maintain its LET performance in the years to come [1]. It also aims to identify the relationship and the most influential among the six attributes: stanine, general weighted average (GWA), honors received, the type of scholarship that the specified respondents have, review center admission, and Licensure Examination for Teachers (LET) remarks with the use of data mining techniques such as Naïve Bayes and C4.5 Algorithms.

2. RELATED LITERATURE

Data mining can be used in the instructive field to overhaul our cognizance of learning strategies to focus on recognizing, removing, and evaluating factors related to the learning strategy of understudies [6].

[5] used understudies' general capacity, assignment execution, class participation and laboratory work, course execution, class test grade, and the past semester marks to anticipate students' imprint toward the end of the semester.

On the other hand, [12] utilized the Naive Bayes arrangement calculation to anticipate student performance in the future semester dependent to prior semester results and conduct. A Naïve Bayes classifier is an essential probabilistic classifier built up on Bayes theory by artless fair-mindedness suppositions. NBC (Naïve Bayes classifiers) was incredibly arranged in managing the instruction area in a rapid manner.

A study of [3] have elaborated that classification is one of the most often examined issues by EDM and AI scientists. Classification is a type of information or data analysis that extracts models describing data classes. A classifier, or classification model, anticipates categorical labels. In their study, the researchers showed that C4.5 is the most suitable algorithm for the model in predicting performance in the Licensure Examination for Teachers.

A study on improving the understudy's performance utilizing Educational Data Mining based by choosing 50 students from Hindustan College of Arts and Science, Coimbatore, India was conducted. Utilizing decision tree classification on eight characteristics, the researcher used the class test, workshop, participation, lab practicums to foresee the student performance in the school. This forecast has assisted the instructor in giving guidance regarding the students' attitude with and trust in their studies [9].

Meanwhile, [13] applied many algorithms such as J48, Naïve Bayes, and wID3's algorithm. By comparing the results of the different algorithms applied, it showed that wID3 classified 93% of records accurately, whereas J48 and Naïve Bayes classified only 78.6% and 75% records, respectively. Therefore, wID3 algorithm is found to be the most efficient among the three.

The Table 1 below shows the synopsis of all the literature review findings. It consists of the research authors, the problem studied, data mining techniques applied, and the accuracy percentage of the results.

Table 1: Related Works

Research Authors	Problem Studied	Used Data Mining Techniques	Accuracy
Kumar and Rhadika [3]	Predicting Student's Board Examination Performance using Classification Algorithms	• C4.5 Decision Tree	• 73.10%
Safeeullah Soomro et al. [12]	Using Naïve Bayes Algorithm to Students' bachelor Academic Performances Analysis	• Naïve Bayes C1 • Naïve Bayes C2 • Naïve Bayes C3	• 96.8% • 93.9% • 98.8%

K.Shanmuga Priya [9]	Educational Data Mining and Analysis of Students' Academic Performance Using WEKA	• Random Forest • PART • J48 • Bayes Net	• 99% • 74.33% • 73% • 65.33%
Ramanathan L et.al.[13]	Predicting Students' Performance using Modified ID3 Algorithm	• Modified ID3 • J48 • Naïve Bayes	• 93% • 76.8% • 75%

3. METHODOLOGY

Predicting student performance in Licensure Examination for Teachers (LET) requires lots of data to be assessed, measured and identified; data that are said to be factors that affect the student performance. Stanine, general weighted average (GWA), honors received, the type of scholarship that the specified respondents have, review center admission, and Licensure Examination for Teachers (LET) remarks are the predictors attribute needed to perform an effective prediction of the student performance in Licensure Examination for Teachers (LET).

3.1 Data Preparation and Pre-processing

Datasets that are used in this paper were accumulated from the Office of the Registrar, Scholarship Office, and Guidance and Testing Office of Davao del Norte State College (DNSC) with the consent of the students and different offices mentioned above. The students, from whom the data used in this study were obtained, are the 2019 graduates from the program Bachelor of Secondary Education (BSEd) in DNSC. The information obtained comes from the 26 BSED-Biological Sciences major students, 27 BSED-Mathematics major students, 43 BSED-TLE major students, and 37 BSED-English major students. Information coming from 31 students were excluded from the list since they did not take the September LET Examination. In total, only 102 were prepared for data mining.

3.2 Data Selection and Transformation

The dataset was obtained from the student academic record of the Bachelor of Secondary Education batch 2018-2019. In this phase, the required information was selected to perform data mining. Stanine, general weighted average (GWA), honors received, the type of scholarship that the specified respondents have, review center admission, and Licensure Examination for Teachers (LET) remarks are collected from the cumulative student form. All the data collected have undergone pre-processing to ensure that all of the data is correct and well-formatted. Enlisted below in table 2 are the predictor and class variables used in the study.

Table 2: Student Variables

Variables	Variable Description	Possible Values
Stud.stanine	Student stanine during the admission test	Numeric {1-9}
Stud.GWA	Undergraduate Student General Weighted Average	{1.0 – 100, 97, 98, 1.25- 97, 96, 95, 1.50- 94, 93, 92, 1.75- 91, 90, 89, 2.0- 88, 87, 86, 2.25- 85, 84, 83, 2.50- 82, 81, 80, 2.75- 79, 78, 77, 3.0- 76, 75, 5.0- 75 below}
Stud.scholarship	Student scholarship while in college	1-CHED Scholar 2-DOST Scholar 3-Iskolar Ng Lungsod 4-GIA Scholar
Stud.honors	Student honors received during graduation	1-Suma Cum Laude 2-Magna Cum Laude 3-Cum Laude 4-First Honors 5-2nd Honors
Stud.review center admission	A student who enrolled in LET Review Centers	1- Yes 2- No
LET_passer	A student who passed/failed the LET Exam	Passed Failed

3.3 Implementation of Data Mining

The authors used specific algorithms for mining the student performance in LET, and these algorithms are found in WEKA [14]. WEKA is free programmed software that is generally utilized in the AI stage. It has an assortment of AI calculations that can be utilized in the use of data mining[15]. Naive Bayes and C4.5 calculations are utilized in the grouping to survey the precision of the subsequent prescient model and to visualize incorrect forecasts. The validation procedure utilized in this study is 10-fold cross-validation and percentage split validation models.

3.4 Naïve Bayes Classifier

Student performance was predicted using the two data mining method, which is C4.5 and Naive Bayes Algorithm. Naive Bayes is a basic probabilistic classifier established on relating Bayes hypothesis by credulous impartiality assumptions and is also used in predicting pertinent variable based on other attributes [16]. NBC (Naïve Bayes classifiers) has been prepared incredibly fast in regulating education area. In this study, this algorithm was used to predict stanine, general weighted average (GWA), honors received, the type of scholarship that the specified respondents have, review

center admission, and Licensure Examination for Teachers (LET) remark. With the help of this algorithm, it can predict the student performance relative to the students' past data [12].

3.5 C4.5 Classifier

The C4.5 classification algorithm is used in representing a useful set of methods [17]. J48 classifier is utilized for generating tree dependent on C4.5 calculations. This calculation was built up by Ross Quinlan [14]. It is also known as a statistical classifier because it generates decision trees that can be used for classifcation [18].

4. RESULT AND DISCUSSION

Using the data stored in student performance dataset, it is found that it can predict the performance of the students. Naïve Bayes and C4.5 algorithm classification models were used to train and test data using WEKA. Table 3 below depicts the algorithm test performance results with the criteria of accuracy, precision for students who passed or failed the LET, AUC, Recall, and F-Measure. Upon using 10-folds cross-validation and 70% percentage split, the algorithm most suitable for the model in predicting student performance can be construed by comparison.

Table 3: Results of C4.5 and Naïve Bayes Algorithm

Criteria	Cross-validation (10 folds)		Percentage Split (70%)	
	C4.5	NBC	C4.5	NBC
Accuracy	86.13%	85.14 %	86.66%	90%
Precision for Passed	0.867	0.901	0.857	0.957
Precision for Failed	0.818	0.650	1.0	0.714
AUC	0.745	0.753	0.833	0.850
Recall	0.861	0.851	0.867	0.900
F-Measure	0.844	0.850	0.838	0.903

Table 3, furthermore, shows the total number of correct predictions. Naïve Bayes has 85.14% and 90% using both 10-fold cross-validation and 70-30 percentage split, respectively, while C4.5 accumulated 86.13% and 86.66% accuracy under the same condition of NBC. The result shows that the Naive Bayes Classification, therefore, generated more accurate predictions than the C4.5 classifications. Figure 1 below shows the True Positive (TP) rate for two classification

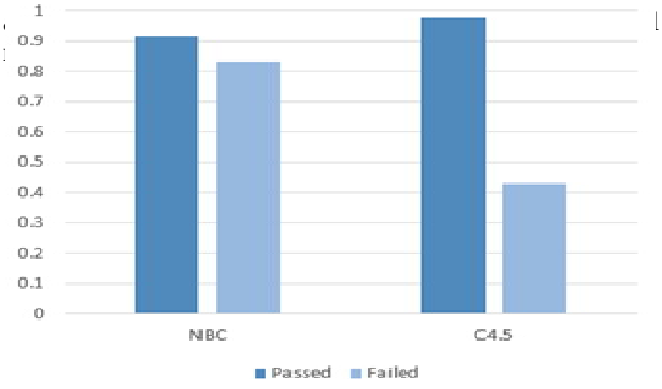

Figure 1: True Positive rate of the two algorithms

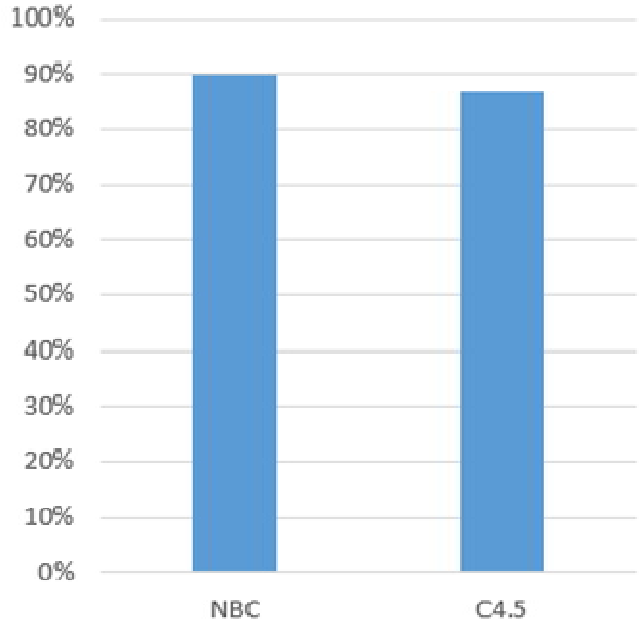

Figure 2: Accuracy of the two algorithms

ROC curve is a useful technique for arranging, improving, visualizing, and evaluating classification models, or classifiers based on their performance. It is also widely used by the decision-making community in the medical field, such as medical diagnostic systems [19]. Moreover, using the ROC curve, Figure 3 and Figure 4 below, graphically presents the trend of students who have passed and failed classes of Naive Bayes. It can be concluded then, that the figures shown below describe the Naive Bayes classification model as capacitated in distinguishing higher prediction accuracy, where the ROC for both passed and failed classes has a higher measure close to 1. For both classes, it is determined that the AUC is 0.8507. Besides, Figures 5 and 6 below, show the ROC curve for passed and failed classes of C4.5 classifier, where AUC measures for both classes gained 0.8333. In comparison, C4.5 classifier is a bit lower compared to Naive Bayes classifiers.

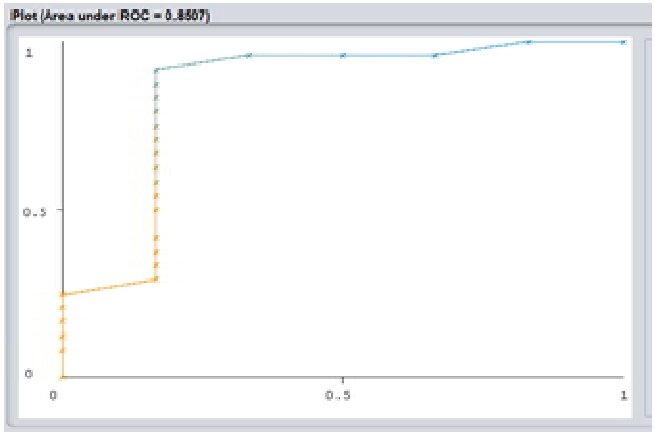

Figure 3: Naive Bayes ROC for Passed Students

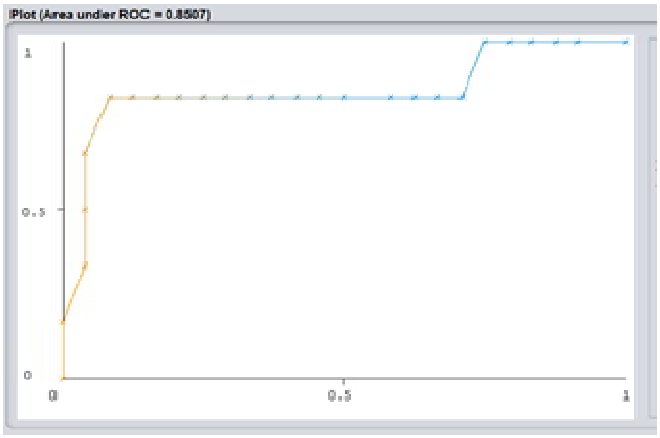

Figure 4: Naive Bayes ROC for Passed Students

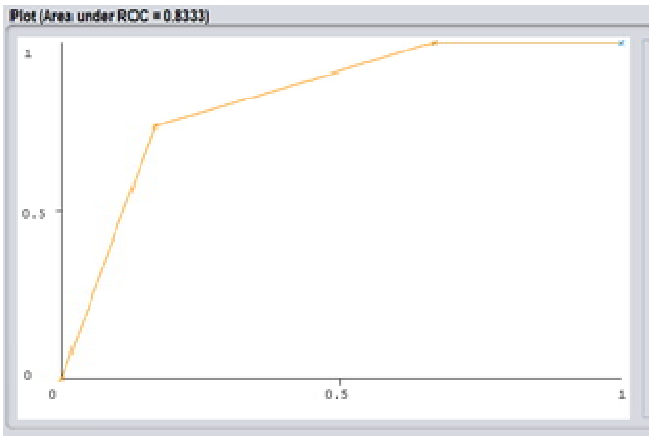

Figure 5: C4.5 ROC for Passed Students

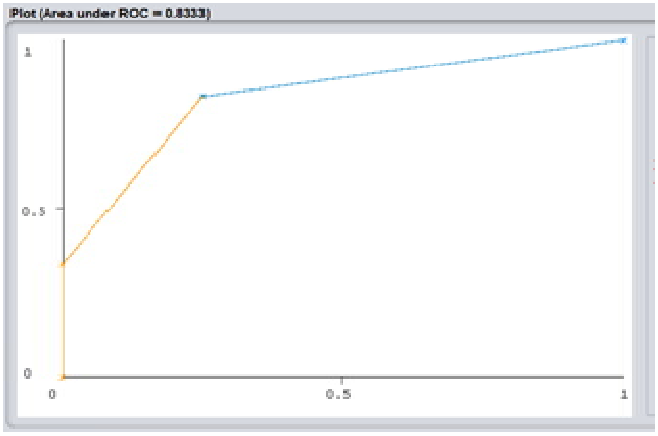

Figure 6: C4.5 ROC for Failed Students

Another objective of this study to be addressed is to identify the most influential attribute that affects the students' performance. With this, assurance of these qualities is characterized by the Gain Ratio esteem. In Table 4, it is shown that the general weighted average (GWA) of the student is the most influential attribute that affects the performance of BSED LET takers of DNSC. Then, admission to LET review centers is the attribute that follows the GWA in affecting student performance in taking LET examination the most.

Table 4: Gain Ratio Attribute Evaluation

Attribute	Value
Student GWA	0.171
A student enrolled in the Review Center	0.132

5. CONCLUSION AND RECOMMENDATIONS

The students' performance was evaluated based on academic and personal data collected from different offices in Davao del Norte State College (DNSC). The total records being collected were 133 with six attributes on which data mining techniques were performed. The main objective of this study is to identify the most influential attribute among the following: stanine, general weighted average (GWA), honors received, the type of scholarship that the specified respondents have, review center admission, and Licensure Examination for Teachers (LET) remarks. With the utilization of Naive Bayes and C4.5 in this study, it is identified that the constant attribute that affects students' performance is their general weighted average (GWA). Thus, with the use of Naive Bayes and C4.5, Davao del Norte State College could be able to predict students who will likely fail or pass the LET examination.

With GWA as the most influential attribute, it is therefore recommended that the college, specifically the Institute of Education (IEd), must maintain their quality instruction wherein educational theories, principles, and concepts are likely taught in an applicable manner.

This study also found out that being enrolled in a LET review centre is also an indicator that affects the students' LET performance. This finding, thus, serves as an implication for the college to upgrade the existing LET review system. The college still conducts LET review; however, over the years, many students choose to enrol in LET review centers outside the college due to some reasons. Having BSED students admitted to the college's LET review sessions is more advantageous. The college can manage students who are performing well and not during reviews, and it can make direct interventions to help the latter keep up. This approach can likely help the college to closely monitor and ensure its status of being one of the top-performing schools in LET for the secondary level. In addition, the lower cost of enrolling in the school's LET review sessions can encourage more BSED students to immediately take the exam since they will no longer have to delay their taking of the exam to earn for their payment when enrolling to outside LET review centers. And before the LET, students, then, must have participated mock board exams. It will reveal the readiness of the college's LET takers and the strength and weaknesses of the LET Review program: which can be used as bases for improvement. Some studies show that mock board performance has a significant relationship in passing the board examination. And aside from mock boards helping the college to get a higher percentage of passers in Licensure

Examination for Teachers (LET), it can be also beneficial for the college accreditation [3].

Moreover, this paper analyzes the capability of data mining techniques, particularly on the performance of Naive Bayes and C4.5 algorithms to achieve the model of academic performance. With various measure metrics, Naive Bayes classification gained 85.14% in 10-folds cross-validation and 90% in the 70% percentage split. The Naive Bayes results were more consistent and more suitable and reliable when testing the data compared to C4.5.

This paper just utilized a few instances, and it is recommended for future examinations to include various information from various years to expand the precision of the prediction. Also, the development of a system that can further detect and analyze the factors that can contribute to predicting students Licensure Examination Performance is proposed.

REFERENCES

[1] M. Solis-Foronda, "Predictors of licensure examination for teachers (LET) performance: A mediation analysis," *ACM Int. Conf. Proceeding Ser.*, vol. Part F1312, pp. 74–78, 2017, doi: 10.1145/3134847.3134863.

[2] A. B. Aquino and L. A. Balilla, "Pre-Service Teachers' Licensure Examination Plans and Content Knowledge," *Asia Pacific J. Educ. Arts Sci.*, vol. 2, no. 2, pp. 110–116, 2015.

[3] R. A. Rustia, M. M. A. Cruz, M. A. P. Burac, and T. D. Palaoag, "Predicting student's board examination performance using classification algorithms," in *ACM International Conference Proceeding Series*, 2018, pp. 233–237, doi: 10.1145/3185089.3185101.

[4] M. Kumar and A. J. Singh, "Evaluation of Data Mining Techniques for Predicting Student's Performance," *Int. J. Mod. Educ. Comput. Sci.*, vol. 8, no. 4, pp. 25–31, 2017, doi: 10.5815/ijmecs.2017.08.04.

[5] B. Kumar and S. Pal, "Mining Educational Data to Analyze Students Performance," *Int. J. Adv. Comput. Sci. Appl.*, vol. 2, no. 6, 2011, doi: 10.14569/ijacsa.2011.020609.

[6] A. K. M. Pal and S. Pal, "Analysis and Mining of Educational Data for Predicting the Performance of Students," *Int. J. Electron. Commun. Comput. Eng.*, vol. 4, no. 5, pp. 1560–1565, 2013.

[7] T. Mauritsius, A. S. Braza, and Fransisca, "Bank marketing data mining using CRISP-DM approach," *Int. J. Adv. Trends Comput. Sci. Eng.*, vol. 8, no. 5, pp. 2322–2329, 2019, doi: 10.30534/ijatcse/2019/71852019.

[8] C. E. Lopez Guarin, E. L. Guzman, and F. A. Gonzalez, "A Model to Predict Low Academic Performance at a Specific Enrollment Using Data Mining," *Rev. Iberoam. Tecnol. del Aprendiz.*, vol. 10, no. 3, pp. 119–125, 2015, doi: 10.1109/RITA.2015.2452632.

[9] K. Priya and A. Kumar, "Improving the Student's Performance Using Educational Data Mining.," *Int. J. Adv. Netw. Appl.*, vol. 4, no. 4, pp. 1680–1685, 2013.

[10] C. Romero, S. Ventura, and E. García, "Data mining in course management systems: Moodle case study and tutorial," *Comput. Educ.*, vol. 51, no. 1, pp. 368–384, 2008, doi: 10.1016/j.compedu.2007.05.016.

[11] C. Romero and S. Ventura, "Educational data mining: A survey from 1995 to 2005," *Expert Syst. Appl.*, vol. 33, no. 1, pp. 135–146, 2007, doi: 10.1016/j.eswa.2006.04.005.

[12] F. Razaque *et al.*, "Using naïve bayes algorithm to students' bachelor academic performances analysis," in *4th IEEE International Conference on Engineering Technologies and Applied Sciences, ICETAS 2017*, 2018, vol. 2018-Janua, no. February, pp. 1–5, doi: 10.1109/ICETAS.2017.8277884.

[13] L. Ramanathan, S. Dhanda, and D. Suresh Kumar, "Predicting students' performance using modified ID3 algorithm," *Int. J. Eng. Technol.*, vol. 5, no. 3, pp. 2491–2497, 2013.

[14] S. Hussain, N. A. Dahan, F. M. Ba-Alwib, and N. Ribata, "Educational data mining and analysis of students' academic performance using WEKA," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 9, no. 2, pp. 447–459, 2018, doi: 10.11591/ijeecs.v9.i2.pp447-459.

[15] K. Bunkar, U. K. Singh, B. Pandya, and R. Bunkar, "Data mining: Prediction for performance improvement of graduate students using classification," *IFIP Int. Conf. Wirel. Opt. Commun. Networks, WOCN*, no. March, 2012, doi: 10.1109/WOCN.2012.6335530.

[16] M. J. Christ, R. N. P. Tri, W. Chandra, and T. Mauritsius, "Lending club default prediction using Naïve Bayes and decision tree," *Int. J. Adv. Trends Comput. Sci. Eng.*, vol. 8, no. 5, pp. 2528–2534, 2019, doi: 10.30534/ijatcse/2019/99852019.

[17] J. S. Mapa, A. M. Sison, and R. P. Medina, "Road traffic accident case status prediction integrating a modified c4.5 algorithm," *Int. J. Adv. Trends Comput. Sci. Eng.*, vol. 8, no. 5, pp. 2622–2625, 2019, doi: 10.30534/ijatcse/2019/114852019.

[18] A. Goyal and R. Mehta, "Performance comparison of Naïve Bayes and J48 classification algorithms," *Int. J. Appl. Eng. Res.*, vol. 7, no. 11 SUPPL., pp. 1389–1393, 2012.

[19] C. S. Hong, "Optimal threshold from ROC and CAP curves," *Commun. Stat. Simul. Comput.*, vol. 38, no. 10, pp. 2060–2072, 2009, doi: 10.1080/03610910903243703.