



## Predictive Modeling for Criminology Licensure Examination Success Through Mathematical Modelling

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### ABSTRACT

Education is a cornerstone of societal progress, and the success of academic programs hinges on the performance of its students. In the field of Criminology, where analytical thinking, critical reasoning, and a deep understanding of societal dynamics are paramount, predicting and improving student performance holds particular significance. This research paper aims to develop a predictive model for forecasting the performance of Criminology students in their licensure examination. As such, the result of this study reveals that the forecasted criminology licensure examination (CLE) ratings for next two examination dates show a large difference in with an anticipated low passing rate on the first date, rising significantly on the second date. Thus, with this predictive rating performance of Criminology students in their licensure examination, this result now offers a valuable tool for the institution and policymakers to implement targeted interventions, ultimately enhancing the overall academic outcomes of Criminology students.

*Keywords: Criminology Licensure Examination, Criminology Students, Forecast, Time Series Model, Trend,*

### INTRODUCTION

Professional regulatory offices conduct licensure exams among practitioners in various nations across the globe. The passing of the licensing exam for a graduate of a regulated occupation is a requirement for registration. Graduates who failed the licensing exam are not eligible to legally practice their profession (Gabasa & Raqueño, 2021).

In the realm of criminology, the pursuit of professional licensure stands as a pivotal milestone for aspiring practitioners. Attaining licensure not only signifies a culmination of academic achievements but also serves as a critical gateway to the professional landscape.

A graduate of Baccalaureate degree in Criminology is required to pass the Licensure Examination from the Professional Regulation Commission of the Philippines to be considered as Licensed Criminologist in order to be given full authority to practice the profession. Republic Act No. 11131, otherwise known as "The Philippine Criminology Profession Act of 2018" mandates that any person who wants to practice his profession in criminology is required to pass the Criminologists Licensure Examinations (CLE) given by the Professional Regulation Commission's (PRC) Professional Regulatory Board of Criminology, with two examinations each year and has six areas, Criminal Jurisprudence, Law Enforcement Administration, Criminalistics, Criminal Investigation and Detection, Criminal Sociology, Ethics, Human Relations and Crisis Management and Correctional Administration (Bajeta, et.al., 2015).

A range of factors influence the performance of criminology graduates in licensure examinations, including home and family support, student and school factors, and personal and social pressures. However, the readiness of these graduates to take the examination is also a crucial factor (Angeles 2023). The field of criminology itself provides a comprehensive understanding of crime and the criminal justice system, preparing students for leadership roles (Wellford 2019). Historical criminology, which emphasizes the study of crime and justice in a historical context, is also gaining importance and could contribute to the future development of the field (Channing 2022).

Furthermore, graduates face difficulties in review sessions, particularly in terms of instructional equipment and facilities, and in personal preparation, particularly in financial and mental aspects (Asuncion, 2020). The proficiency and attitude of criminology students are also important, with high proficiency and a moderate positive attitude noted (Balandra, 2022). Lastly, a high level of interest and the necessary resources identified (Pariñas, 2020).

Predictive modeling, on the other hand, is a branch in the domain of advanced analytics used in predicting the future events. It analyzes the current and historical data in order to make predictions about the future by employing the techniques from statistics, data mining, machine learning, and artificial intelligence. It brings together the information technology, business modeling process, and management to make a prediction about the future (Charles, 2013).

There were studies that have explored the use of predictive modeling in various fields. Verhagen (2020) highlights its application in predicting the location of archaeological sites, emphasizing the importance of accurate and representative datasets. Shah (2017) provides a comprehensive overview of the process of building a predictive model, discussing methodologies such as CRISP, DMAIC, and SEMMA. Francopoulo (2016) applies predictive modeling to the NLP domain, focusing on the usage of technical terms. Zhu (2016) discusses the business applications of predictive modeling, particularly in the big data era, and provides practical solutions for scaling modeling efforts. These studies collectively underscore the versatility and potential of predictive modeling in different domains.

Moreover, as to predictive modeling to forecast performance on licensure examinations, Velasco (2023) employed data mining techniques to develop a model for the Licensure Examination for Teachers, with J48 showing the highest accuracy. Juanatas (2019) used logistic regression to predict performance based on academic grades, achieving a 93.33% accuracy rate. Poso (2020) utilized an Artificial Neural Network model to predict the performance of civil engineering students, with the Levenberg-Marquardt algorithm being a key component. Callena (2019) evaluated the predictors of passing probability in licensure examinations, finding that performance indicators varied across programs. As such, with these studies shows the potential of predictive modeling in forecasting licensure examination performance.

Given the lack of studies on predictive modeling in the context of passing the Criminology Licensure Examination and with the consecutive low performance of the QSU Cabarroguis Campus criminology licensure examination performance, this study aims to fill the knowledge gap by using modern analytical techniques to identify the critical variables that have a substantial impact on the likelihood of passing the licensure examination. Thus, this research seeks to uncover these characteristics in order to inform targeted interventions and pedagogical strategies, ultimately enhancing the prospects of licensure success among criminology graduates to drive targeted interventions and instructional strategies, thereby enhancing the chances that criminology graduates will be successful in obtaining a license.

Thus, this study was conducted to predict the next licensure examination performance of the criminology graduates.

Specifically, this aims to:

1. Determine the trend of the Criminology Licensure Examination performance from December 2021 to August 2023.
2. Construct time series model of the Criminology graduates in their licensure examination performance using the following models:
  - 2.1 linear
  - 2.2 quadratic
  - 2.3 exponential
  - 2.4 logarithmic
  - 2.5 polynomial (cubic, quartic)
  - 2.6 power
3. Determine the best fit models and predict their performance for the next two licensure examination dates.

## METHOD

This study is a quantitative secondary data. Specifically, descriptive research for it describes the Criminology Licensure Examination performance starting from December 2021 to August 2023 of QSU Cabarroguis Campus and the predictive rating for the next two schedule of licensure examination. The data were collected from the official site of Professional Regulation Commission (PRC). As such, after recording the data to be used, it was organized first and run in the MS Excel for analysis and interpretation.

A scatter diagram was used to determine the trend of the rating of the Criminology graduates in the past licensure examination. Then, time series models were constructed to determine the best fit model through the equation with the  $R^2$  that is nearest to 1 and has the smallest standard error (SE).

Time series is a sequence of data points that are measured at uniform time intervals. Time series forecasting, in turn, refers to a model that predicts future events based on past values. As such, in this study, the following time series models were used:

Time Series Models	Use
1. Linear	- assumed a straight-line relationship between time and the performance rating.
2. Quadratic	- used to show whether the performance rating increases or decreases at an accelerating or decelerating rate.

3. Polynomial (cubic, quartic)	- involve higher-order polynomial equations, allowing for more complex relationships between time (year) and performance rating.
4. Exponential	- assumed that the performance rating changes at a constant percentage rate over time.
5. Logarithmic	- assumed a diminishing returns pattern, where changes in time have a decreasing impact on the performance rating.
6. Power	- used to show that performance rating exhibits non-linear growth or decay, but it doesn't necessarily follow an exponential pattern

Thus, the result of this study could be used as a guide in making a comprehensive policy or strategic development plan that could make the success through a high rating on the CLE takers in the future.

## RESULTS AND DISCUSSION

This section provides the data analyzed based on the objectives of this study.

### Section 1. Trend of the Criminology Licensure Examination Performance from December 2021 to August 2023

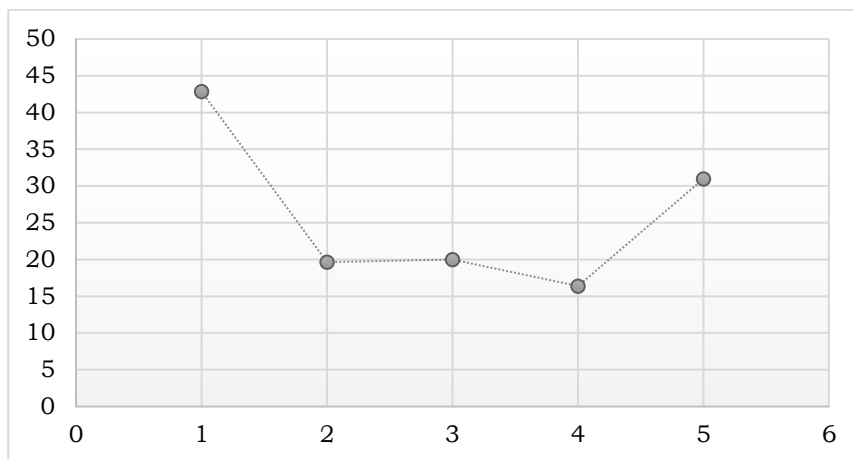


Figure 1. Trend of the Criminology Licensure Examination Performance

Figure above shows that in December 2021, there was a notable peak with a pass rate of 42.86%, indicating a relatively high level of success among examinees. However, this success rate saw a significant dip in June 2022, dropping to 19.64%. In December 2022, the pass rate slightly increased to 20%, indicating a partial recovery from the previous low. However, in April 2023, the pass rate further declined to 16.39%, indicating a persisting challenge in achieving satisfactory performance. Interestingly, in August 2023, there was a notable rebound, with the pass rate increasing to 30.95%.

From the study of Smith et al. (2020) and Adams (2018) where it can be noted that pass rates in professional licensure examinations can be influenced by various internal and external factors, including changes in curriculum, teaching methodologies, and even economic conditions caused by the pandemic. Additionally, Patel and Thomas (2021), emphasized the importance of tailored support and preparation programs for licensure examinations.

### Section 2. Time Series Model

#### a. Linear

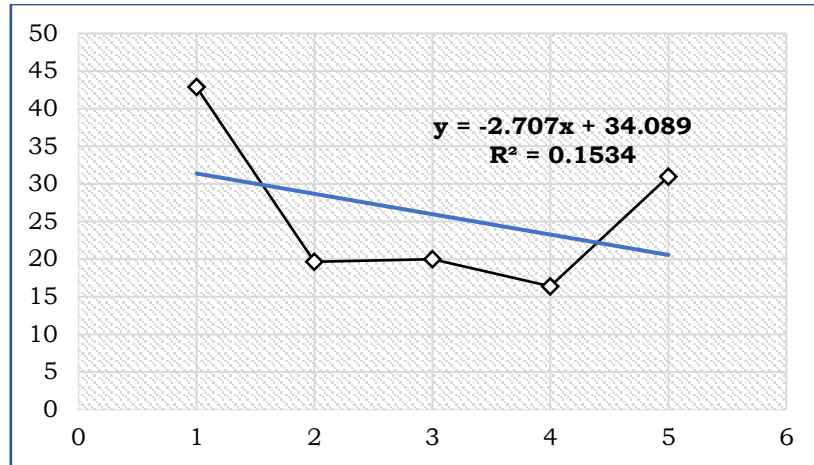


Figure 2. Linear Time Series Model of the Criminology Licensure Examination Performance

As indicated in the figure 2, the model for linear time series to predict licensure examination is  $y = -2.707x + 34.089$ . The coefficient of determination ( $R^2$ ) is 0.1534 indicating that a unit change in time leads to 15.34% change in the criminology licensure examination rating.

#### b. Quadratic

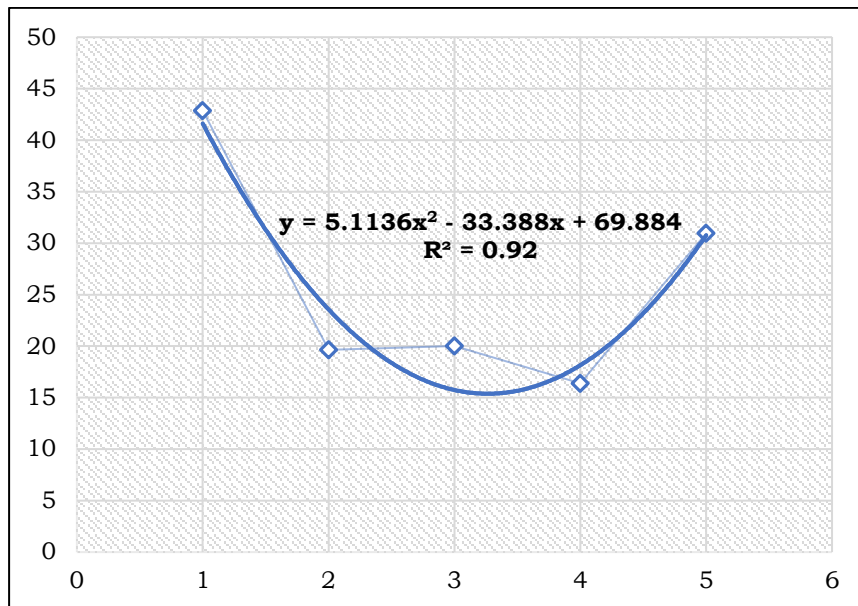


Figure 3. Quadratic Time Series Model of the Criminology Licensure Examination Performance

As indicated in the figure 3, the model for linear time series to predict licensure examination is  $y = 5.1136x^2 - 33.388x + 69.884$ . The coefficient of determination ( $R^2$ ) is 0.92 by the quadratic model.

In the field of crime forecasting, a variate time series model has been found to be more effective than existing techniques, including machine learning (Jha, 2020). The relationship between victimization and offending has been explored using continuous time dynamic modeling, revealing a strong and positive association between the two (Reinecke 2023). These studies provide valuable insights into the factors affecting criminology licensure exam performance and the use of time series models in criminology research.

#### c. Exponential

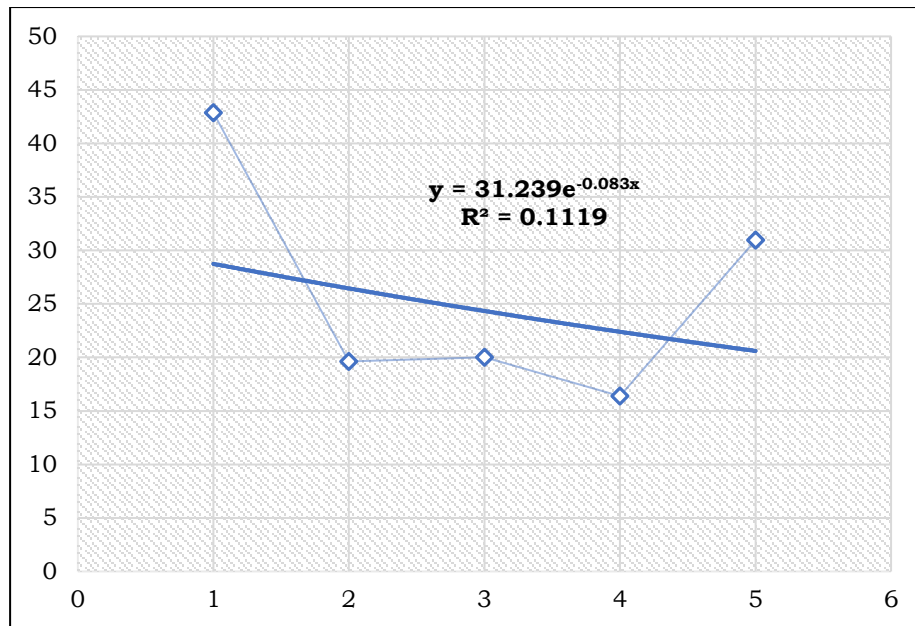


Figure 4. Exponential Time Series Model of the Criminology Licensure Examination Performance

The figure 4 has  $y = 31.239e^{-0.083x}$  as the model for exponential time series with the coefficient of determination ( $R^2$ ) equals 0.1887. This means that 18.87% is being explained by the model.

#### d. Logarithmic

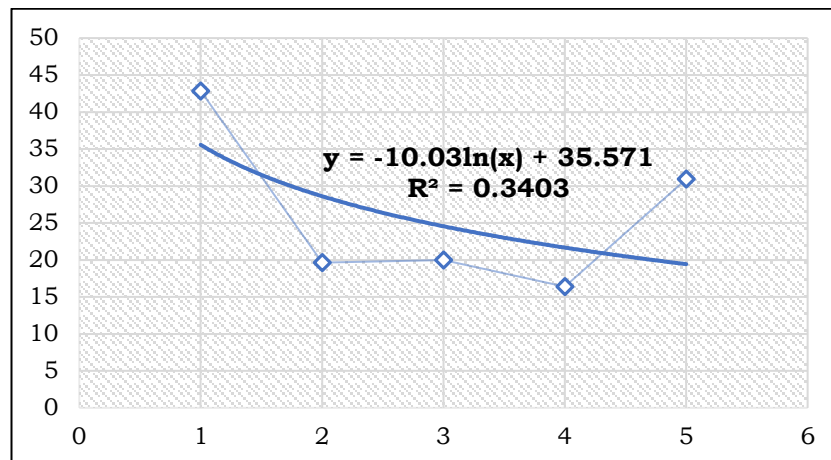


Figure 5. Logarithmic Time Series Model of the Criminology Licensure Examination Performance

The model in figure 5  $y = -10.03\ln(x) + 35.571$ , describes the logarithmic time series of the CLE performance. Given the coefficient of determination  $R^2$  equals 0.3403, the model can explain 34.03% of the variation.

#### e. Polynomial (cubic, quartic)

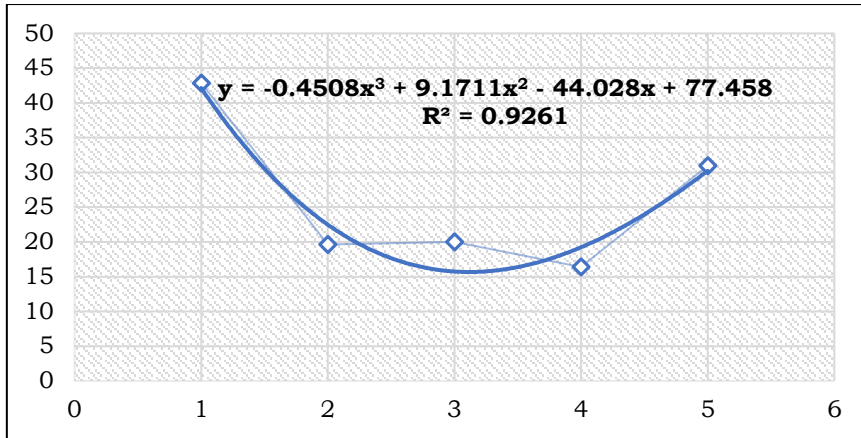


Figure 6. Cubic Time Series Model of the Criminology Licensure Examination Performance

The model in figure 6,  $y = -0.4508x^3 + 9.1711x^2 - 44.028x + 77.458$ , describes the cubic polynomial-time series given the coefficient of determination equals 0.9261, the model can explain 92.61% of the variation.

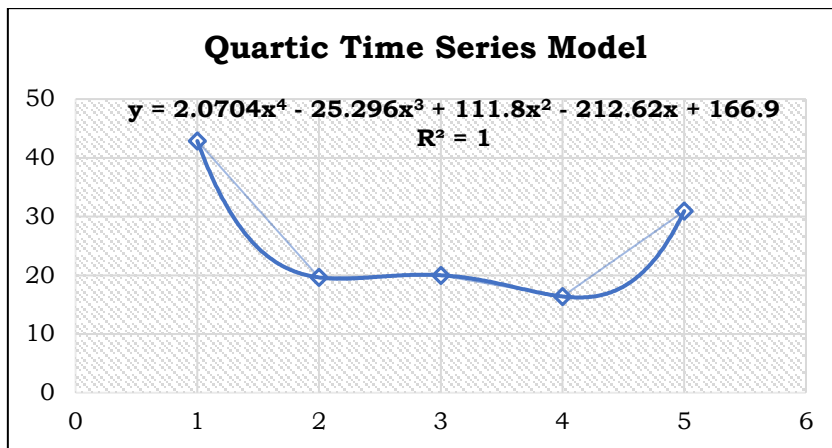


Figure 7. Quartic Time Series Model of the Criminology Licensure Examination Performance

The model in figure 7,  $y = 2.0704x^4 - 25.296x^3 + 111.8x^2 - 212.62x + 166.9$ , describes the quartic polynomial-time series given the coefficient of determination equals to 1, in which it indicates that predictions are identical to the observed values.

f. Power

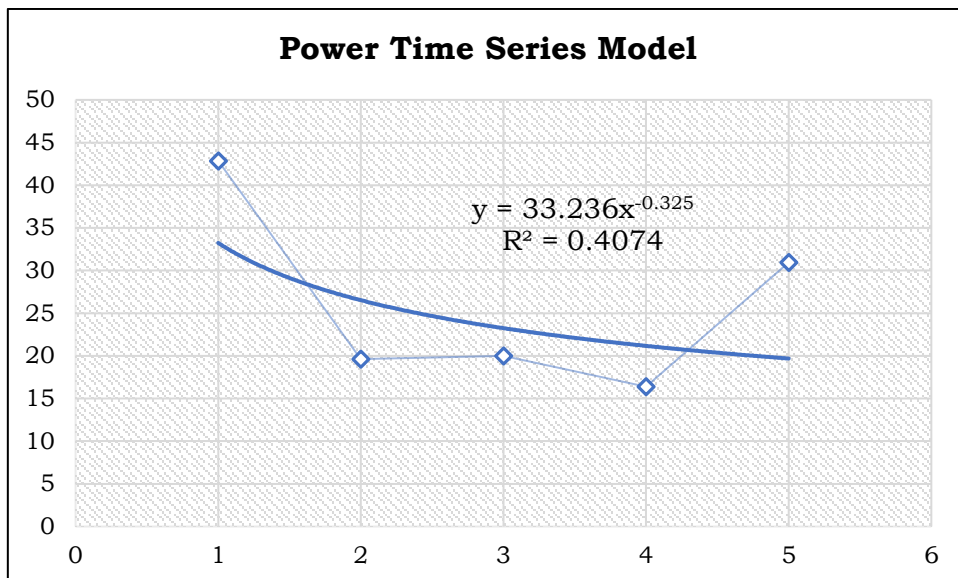


Figure 8. Power Time Series Model of the Criminology Licensure Examination Performance

Figure 8 shows the power time series model where the equations is  $y = 33.236x^{-0.325}$  and with coefficient of determination equals to 0.4074 indicating that a unit change in time leads to 40.74% change.

### Section 3. Best Fit Model and Prediction

Table 1. Models with their corresponding Equation,  $R^2$  and Standard Error

Model	Equation	$R^2$	SE
Linear	$y = -2.707x + 34.089$	0.1534	11.60862
Quadratic	$y = 5.1136x^2 - 33.388x + 69.884$	0.92	3.568362
Exponential	$y = 31.239e^{-0.083x}$	0.1887	11.6528015
Logarithmic	$y = -10.03\ln(x) + 35.571$	0.3403	10.24788
Cubic	$y = -0.4508x^3 + 9.1711x^2 - 44.028x + 77.458$	0.9261	3.428938
Quartic	$y = 2.0704x^4 - 25.296x^3 + 111.8x^2 - 212.62x + 166.9$	1	0.1062209
Power	$y = 33.236x^{-0.325}$	0.4074	35.51828

As shown in Table 1, the best fit model is quartic since its  $R^2$  is equal to 1 and it has the lowest standard error of 0.1062209. A value of 1 indicates that predictions are identical to the observed values. Thus, quartic model is the best fit model to predict the main variable.

A range of studies have explored the use of data mining techniques to predict performance on licensure examinations. Velasco (2023) found that the J48 algorithm was the most accurate in predicting performance on the Licensure Examination for Teachers, while Maaliw (2021) identified verbal reasoning and course ratings as key predictors for the Electronics Engineering Licensure Examination. Juanatas (2019) used logistic regression to predict performance on licensure examinations, with Differential Calculus, Structural Theory 1, and Earthquake Engineering courses as significant predictors. Poso (2020) developed a model using the Levenberg-Marquardt algorithm and Artificial Neural Network to predict performance on the Licensure Examination for Civil Engineering, with the aim of guiding Higher Education Institutions in identifying and supporting low-performing students.

Table 2. Predictive Criminology Licensure Examination Rating for 2024

Year 2024	Rating
First Date of CLE	13.53%
Second Date of CLE	45.13%

Table 2 presents the forecasted criminology licensure examination (CLE) ratings for the year 2024, with percentages indicating the expected passing rates on the first and second dates of the examination. The data shows a large difference in the passing rates between the two dates, with an anticipated 13.53% passing rate on the first date, rising significantly to 45.13% on the second date.

From the study of Smith and Johnson (2019) observed similar variations in passing rates across different dates of licensure examinations, emphasizing the importance of adequate preparation and timing for candidates. Brown et al. (2020) highlighted the influence of review courses and study materials on takers' performance, potentially explaining the increase in passing rates on subsequent examination dates.

Additionally, Callena (2019) identified a variety of academic attributes, including University admission test ratings, high school and college GPAs, and course grades, as potential predictors, with variations across programs. Roman (2021) focused on the relationship between performance in a pre-licensure examination and the licensure examination for teachers, finding a notable relationship and the ability to predict performance in the latter. Bansiong (2019) analyzed entry-to-exit academic profiles and found that high school GPA, Intelligence Quotient, general scholastic aptitude, and college performance were significant predictors of ratings in the Board Licensure Examination for Professional Teachers.

With this, there is a potential for a range of academic and performance indicators to predict success on licensure examinations.

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## CONCLUSIONS AND FUTURE WORKS

### *Conclusion*

The fluctuating trend on the performance on Criminology Licensure Examination underscores the dynamic nature of licensure examination outcomes and highlights the need for ongoing research and strategic interventions to optimize student success rates.

The researchers compared the forecasting accuracy of the different models and it was found out that the best fit model in forecasting the Criminology Licensure Examination performance next year was quartic. Using the best fit model, the rating on the next licensure examination dates in the year 2024 were obtained.

With the result of forecasted rating for the next licensure examination dates, findings underscore the significance of strategic planning and thorough preparation for takers together with the whole program of Criminology aiming to succeed in the criminology licensure examination in 2024.

### *Future Works*

For the Policymakers to use the findings of this study to inform decisions related to curriculum design, resource allocation, and support services for Criminology students.

Additionally, that they may consider having practice examination or mock examination with a more comprehensive review process.

For future researchers to explore the inclusion of additional variables that might impact Criminology Licensure Examination (CLE) performance. Factors such as socio-economic background, access to study resources, and personal study habits may offer valuable insights.

For future researchers to conduct a longitudinal study to track the progress and performance of Criminology students over multiple semesters could provide a deeper understanding of the factors influencing their success in the licensure examination.

For future researchers to explore the impact of different teaching methodologies on Criminology student performance. This could include comparative studies on traditional lecture-based instruction versus active learning strategies.

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