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Enhancing Educational Support: Cart-Based Framework for Classifying Criminology Students

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***Abstract*— The study investigates criminology students' academic performance, support needs, and engagement from the 2nd to 4th year in the 2023-2024 school year. Data was collected through a structured questionnaire, measuring perceptions of academic support, resource access, career counselling, and engagement in academic and extracurricular activities. The CART framework was used to analyse the data, identifying key factors influencing student engagement and support needs. Results showed moderate academic support, fair resource access, and general learning motivation. Engagement levels were positively correlated with perceptions of support and belonging, but some students reported feeling disconnected from their program. The study suggests improved support mechanisms and resources, particularly in career counselling and fostering a sense of community within the criminology program.**

***Keywords*— Decision Tree Analysis, CART Algorithm, Criminology education, Academic Engagement, Academic performance factor, Student support systems, Student motivation, Higher education support needs, Performance attribute.**

I. INTRODUCTION

One of the significant challenges identified with any institution of learning, and certainly within criminology courses, was identifying who might have issues with academic performance or disengage themselves from their courses of study. In the case of the University of Iloilo, the challenge is that it usually involves various problems in providing the help needed by students of criminology whose academic performance varies, engagement patterns vary, and the type of support required varies. It had already been shown that support strategies treating everybody the same way were inefficient in addressing the problems various kinds of students encountered. Low attendance, behavioural issues, and inadequate engagement in academic work have all emerged as widespread challenges in school that lead to high dropout rates and underperformance. There is thus a strong imperative to move to an even more data-informed and targeted form of classification of pupils against specific needs and performance attributes to enact appropriately targeted interventions that can improve educational outcomes.

Understanding Decision Tree Algorithms from Analytics Vidhya highlights that while Decision Trees are straightforward and widely used for various tasks, they have limitations such as overfitting, especially in complex datasets. Many algorithms can be used with Decision Trees, but not all work well for every situation. Some methods are better at analysing complex data and providing valuable insights. While various Decision Tree algorithms exist, more straightforward implementations often struggle with issues like overfitting, especially in complex datasets. Many algorithms can be used with Decision Trees, but not all work well for every situation. Decision Trees in Machine Learning from DataQuest provides insights into Decision Trees and their challenges. It mentions that more straightforward Decision Tree implementations may not perform as effectively as more sophisticated frameworks like CART, which incorporates cost-complexity pruning and can handle data more robustly. The article elaborates on the features and drawbacks of different Decision Tree algorithms, emphasising the advantages of CART over basic implementations.

The study aims to develop a CART-based framework for criminology students of the University of Iloilo. This study will categorise the students according to the most critical performance factors: behaviour, attendance, academic achievement, support needs, and engagement. CART is used here to find trends or classify students according to their unique academic strengths and weaknesses. Ultimately, it will make it possible for educators to provide a particular, evidence-based model by which to tailor educational interventions. The strategy thus adopted by the university will enable the university to better respond to the uniqueness of its students within the criminology major, thereby enhancing retention, academic achievement, and all-around student success.

II. RELATED STUDIES

2.1. Using Decision Tree Algorithm to Predict Student Performance

Apolinar-Gotardo's (2019) study employs the J48 algorithm to create a decision tree model that predicts student performance in data structures and algorithms. It analyses data from 2nd-year BSIT students, finding that finals significantly impact performance, with accuracy rates of 85.31% for passing, 79.41% for conditional, and 91.67%

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for failing. To pass, students must achieve grades over 66.12% in midterms and 72.30% in finals. The study suggests that data-driven systems can enhance academic tracking and policy-making for intervention programs.

2.2. Student's Performance Analysis Using Decision Tree Algorithms

Olaniyi et al. (2017) explore the application of Educational Data Mining (EDM) to analyse student performance in CSC207 (Internet Technology and Programming I) using various decision tree algorithms, including BFTree, J48, and CART. It utilises attributes such as attendance, class tests, lab work, assignments, and previous semester marks to predict performance in the final examination. The findings indicate that BFTree is the most effective classification algorithm, achieving a 67.07% accuracy in correctly classifying student performance.

2.3. Building Student's Performance Decision Tree Classifier Using Boosting Algorithm

Jauhari and Supianto (2019) investigate using three boosting algorithms (C5.0, AdaBoost.M1, and AdaBoost. SAMME) to predict student performance using the UCI student performance dataset. It evaluates the algorithms through three scenarios: the first compares their performance with 10-fold cross-validation, showing that adaBoost.
SAMME and adaBoost.M1 excel in binary classification. The second scenario assesses the algorithms with varying training data, where adaBoost.M1 again performs best. The third scenario demonstrates that models trained on one subject's dataset can effectively predict outcomes in another subject.

III. PURPOSE OF THE STUDY

This study sets up and implements a CART-based framework that can be applied to categorise criminology students at the University of Iloilo according to other key performance attributes like attendance, behaviour, academic performance, support needs, and engagement. The study shall then identify distinct patterns of student performance or group students according to their uniquely different academic challenges by using the CART algorithm. This categorisation will allow educators to craft focused educational interventions targeting specific needs. Thus, it builds support from the students who directly impact academic outcomes. It also aims to delineate factors contributing to students' criminology success, providing a more welcoming climate for learning. Last, this research focuses on the small contribution to the existing body of knowledge on successful educational support in higher education.

IV. SIGNIFICANCE OF THE STUDY

4.1. University

This study helps the university understand how criminology students perform and what support they need. Knowing these factors allows the university to improve its programs and resources, improving student satisfaction and success.

4.2. Faculty

For teachers, the study provides insights into how students feel about the support they receive. This information can help faculty adjust their teaching methods and create a more supportive learning environment, making it easier for students to engage and succeed.

4.3. Students

The findings directly impact students by highlighting their experiences and challenges in the criminology program. By sharing this information, students can push for better resources and support services, creating a stronger sense of community and collaboration among peers.

4.4. Future Researchers

This research sets a foundation for future studies about student performance and engagement. Other researchers can use this study as a starting point to explore new ideas and improve educational practices, helping to understand better what students need to succeed.

V. METHODOLOGY

5.1. Research Design

This study utilises a quantitative research approach, leveraging Classification and Regression Trees (CART) to analyse and classify criminology students based on critical performance indicators like attendance, behaviour, academic performance, support needs, and engagement. The CART algorithm recursively splits the data into subsets, creating a decision tree that categorises students into distinct performance levels. The process identifies the most significant factors influencing student performance, allowing educators to classify students into different groups effectively. This framework is valuable for designing targeted interventions to improve student outcomes by addressing specific needs identified through the classification process.

The research design of this study incorporates a mathematical approach by utilising conditional logic through an Excel formula, which systematically classifies criminology students based on their performance indicators. The formula is designed as a piecewise function, where the input variable, denoted as H, represents a student's performance score, and the output categorises the score into qualitative assessments: "Very Poor," "Poor," "Average," "Good," or "Excellent." This classification

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follows a step function, where specific intervals of H are mapped to corresponding categorical outcomes. The boundaries of these intervals are defined using conditional statements, ensuring that the classification aligns with the performance range. This mathematically rigorous approach allows for an objective and replicable method of categorising student performance, providing a clear and quantifiable framework for analysis. The integration of piecewise functions within the research design exemplifies the application of mathematical principles in educational research, enhancing the study's validity and precision.

The conditional formula provided can be expressed mathematically as a piecewise function, denoted as $f(H)$, where H represents the performance score:

$$f(H) = \begin{cases} \text{"Very Poor"} & \text{if } 1 \leq H < 2 \\ \text{"Poor"} & \text{if } 2 \leq H < 3 \\ \text{"Average"} & \text{if } 3 \leq H < 4 \\ \text{"Good"} & \text{if } 4 \leq H < 5 \\ \text{"Excellent"} & \text{if } H = 5 \\ \text{"Invalid"} & \text{otherwise} \end{cases}$$

This piecewise function defines the classification of students' performance into five distinct categories based on the range in which H falls. Each interval of H corresponds to a qualitative label, ensuring precise categorisation based on the student's scores. This mathematical structure forms the basis for the classification system employed in the study, offering an accurate and formalised method for evaluating student performance.

5.2. Participants

The participants of this study are criminology students enrolled in the 2nd, third, and fourth years of their academic program during the 2023-2024 school year, specifically in the 2nd semester. These students represent diverse educational experiences and stages in their criminology education, allowing for a comprehensive analysis of performance trends across multiple levels. By focusing on these year levels, the study aims to capture a broad spectrum of student behaviours, attendance patterns, and academic engagement. It provides a clearer understanding of how these factors evolve as students progress through their criminology curriculum.

5.3. Instruments

The data gathering instrument utilised in this study is a 10-item, validated, researcher-made learning preferences questionnaire. Each criterion, such as attendance, behaviour, academic performance, support needs, and engagement, consists of 10 questions for students to answer, ensuring a comprehensive assessment of their performance attributes. The collected responses will be analysed using the CART (Classification and Regression Tree) algorithm, allowing for the identification of patterns and classification of students based on these key performance indicators. This approach ensures the data is systematically gathered and rigorously analysed to inform targeted educational interventions.

5.4. Data Gathering Procedure

The data-gathering procedure involved administering the researcher-made questionnaire to criminology students through Google Forms. This method allowed for efficient and accessible data collection, ensuring students from the 2nd, third, and fourth years could easily participate. The responses were automatically recorded and compiled in a secure digital format.

5.5. Data Analysis

In the data analysis phase, the responses from the Google Forms were processed and analysed using the CART (Classification and Regression Tree) algorithm. This method allowed for identifying patterns and classifying students into distinct performance categories based on key indicators such as attendance, behaviour, academic performance, support needs, and engagement. The CART analysis provided clear decision rules, helping to determine which factors most significantly influenced student outcomes. The results were then interpreted to guide targeted educational interventions.

The conditional formula provided can be expressed mathematically as a piecewise function, denoted as $f(H)$, where H represents the performance score:

$$f(H) = \begin{cases} \text{"Very Poor"} & \text{if } 1 \leq H < 2 \\ \text{"Poor"} & \text{if } 2 \leq H < 3 \\ \text{"Average"} & \text{if } 3 \leq H < 4 \\ \text{"Good"} & \text{if } 4 \leq H < 5 \\ \text{"Excellent"} & \text{if } H = 5 \\ \text{"Invalid"} & \text{otherwise} \end{cases}$$

This piecewise function defines the classification of students' performance into five distinct categories based on the range in which H falls. Each interval of H corresponds to a qualitative label, ensuring precise categorisation based on the student's scores. This mathematical structure forms the basis for the classification system employed in the study, offering an accurate and formalised method for evaluating student performance.

This function describes the total classification of students based on performance indicators like academic performance, attendance, behaviour, support needs, and engagement, similar to the conditional logic used in the CART model. Each range of Uleads corresponds to a different student evaluation, providing a structured approach to categorising overall performance.

The measurement of interventions in this study is grounded in a systematic assessment of student performance using the CART framework. We can

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effectively identify areas requiring intervention by categorising students based on their scores from various attributes such as academic performance, attendance, behaviour, support needs, and engagement. The formula generates specific classifications ranging from "Very Poor" to "Excellent," allowing for targeted educational support tailored to each student's unique needs. This method facilitates identifying students needing immediate assistance and provides a structured approach to track improvements over time. Ultimately, the outcomes derived from this measurement will guide the development of interventions to enhance student success and overall academic performance.

$$f(U) = \begin{cases} \text{"Very Poor"} & \text{if } 1 \leq U < 2 \\ \text{"Poor"} & \text{if } 2 \leq U < 3 \\ \text{"Average"} & \text{if } 3 \leq U < 4 \\ \text{"Good"} & \text{if } 4 \leq U < 5 \\ \text{"Excellent"} & \text{if } U = 5 \\ \text{"Invalid"} & \text{otherwise} \end{cases}$$

The explanations for each category are simplified as follows:

- **Very Poor**: Severe deficiencies in all areas
- **Poor**: Inconsistent performance and low engagement
- **Average**: Moderate performance with some issues
- **Good**: Strong performance with minor issues
- **Excellent**: Exceptional performance across all areas

VI. RESULTS AND DISCUSSION

6.1. Respondents

The study involves 67 criminology students from the second to the fourth year. This group includes students at different stages of their studies, which helps us understand their experiences better. By including students from various years, we can see trends and common challenges they face. Their feedback will help us identify what support they need in their academic journey. This information is essential for creating solutions that meet the specific needs of criminology students at each level.

Table 1. Academic Performance

Academic Performance			
No.	Category	Mean	SD
1	I consistently achieve high grades in my criminology courses.	2.9	1.1
2	I am able to manage my study time effectively for criminology subjects.	3.1	1.3
3	I frequently seek help from professors when I do not understand the materials.	2.9	1.2
4	I participate actively in criminology class discussions.	3.0	1.4
5	I can connect theoretical knowledge from my criminology courses to practical applications.	3.0	1.2
6	I am confident in applying criminology theories to real-world scenarios.	3.0	1.4
7	I find the assessment in my criminology courses fair and reflective of my knowledge.	3.0	1.4
8	I am confident in my ability to perform well on criminology exams.	3.1	1.4
9	I receive constructive feedback from my professor that helps me improve.	3.1	1.4
10	I believe my criminology education prepares me well for a career in the field.	3.3	1.6

The data reveals that criminology students generally perceive their academic performance as moderately satisfactory, with mean scores between 2.9 and 3.3. While students feel confident in their participation and application of theoretical knowledge, they are uncertain regarding their grades and seek help when necessary. These findings underscore the need for targeted interventions to improve student engagement and self-efficacy in the criminology program.

Table 2. Attendance

Attendance			
No.	Category	Mean	SD
1	I attend all my criminology classes regularly.	3.34	1.85
2	I am punctual and arrive on time for my criminology classes.	3.15	1.70
3	I prioritise attending my criminology classes over other commitments.	3.18	1.71
4	I feel that attending classes regularly improves my academic performance.	3.34	1.75
5	I make up for any missed classes by reviewing lecture notes and materials.	2.97	1.45

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Attendance			
No.	Category	Mean	SD
6	I participate actively in class when I attend my criminology courses.	3.04	1.59
7	I inform my professors beforehand if I have to miss a class.	2.91	1.44
8	I find it easy to keep track of my attendance in my criminology courses.	3.12	1.62
9	I believe that poor attendance negatively affects my understanding of the course material.	3.10	1.66
10	I am motivated to attend all my criminology classes.	3.01	1.75

The data on attendance indicates that criminology students generally exhibit a positive attitude towards their attendance habits, with mean scores ranging from 2.91 to 3.34. Students feel particularly strongly about the importance of regular class attendance and its impact on their academic performance, though there are lower scores related to making up for missed classes. These findings suggest a need for support systems to encourage consistent attendance and address the challenges of class participation.

Behaviour			
No.	Category	Mean	SD
1	I adhere to the university's code of conduct in my criminology classes.	2.97	1.58
2	I show respect towards my professors and peers during criminology classes.	3.28	1.74
3	I actively participate in criminology class discussions and activities.	3.06	1.61
4	I handle conflicts with classmates maturely and constructively.	3.01	1.52
5	I refrain from disruptive behaviour during criminology lectures.	3.10	1.58
6	I am responsible for submitting my criminology assignments on time.	3.16	1.69

Behaviour			
No.	Category	Mean	SD
7	I seek help from professors when I do not understand criminology material.	2.96	1.58
8	I take responsibility for my own learning and academic performance in criminology.	3.04	1.66
9	I show a positive attitude towards my criminology studies.	2.99	1.75
10	I demonstrate good time management skills in balancing my criminology studies and other activities.	3.01	1.56

The behaviour data reveals that criminology students generally exhibit a positive outlook regarding their conduct and responsibilities, with mean scores ranging from 2.96 to 3.28. Notably, students feel most confident in respecting their professors and peers and taking responsibility for submitting assignments. However, there are lower scores related to adherence to the university's code of conduct and seeking help, suggesting that while students value positive behaviour, some areas require further attention and support.

Table 3. Support Needs

Support Needs			
No.	**Category**	**Mean**	**SD**
1	I receive adequate academic support from my professors.	2.85	1.47
2	I have access to the necessary academic resources to succeed in my criminology courses.	3.00	1.50
3	The university provides sufficient career counselling and guidance for criminology students.	3.09	1.49
4	I feel supported by my family in my academic pursuits.	3.24	1.52
5	I can easily access mental health and wellness services provided by the university.	3.07	1.33
6	I find it easy to get academic help from my peers.	2.99	1.31
7	The university offers sufficient financial aid and scholarships for criminology students.	3.15	1.49

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Support Needs			
No.	**Category**	**Mean**	**SD**
8	I am aware of and use tutoring services available for criminology subjects.	2.91	1.42
9	I feel that the administrative staff helped address my academic concerns.	3.04	1.55
10	I receive encouragement and support from my friends in the criminology program.	3.22	1.56

Students express mixed feelings about the academic support they receive, with a mean score of 2.85 indicating a moderate level of satisfaction and a high standard deviation (SD = 1.47) showing variability in perceptions. Access to necessary academic resources scores slightly better at 3.00 (SD = 1.50), suggesting some students lack essential tools for success. Career counselling services are perceived as sufficient (mean = 3.09, SD = 1.49), but the variability indicates that not all students feel adequately supported.

Table 4. Engagement

Engagement			
No.	**Category**	**Mean**	**SD**
1	I am actively engaged in my criminology classes.	3.06	1.69
2	I find the course material in my criminology program interesting and stimulating.	3.03	1.51
3	I regularly participate in class discussions and activities.	3.16	1.58
4	I feel a sense of belonging in my criminology program.	2.99	1.57
5	I am motivated to learn and succeed in my criminology courses.	3.10	1.71
6	I attend and participate in extracurricular activities related to criminology.	3.00	1.51
7	I engage with the course content outside of class (e.g., through additional reading and research).	2.91	1.46
8	I feel that my professors make the course content engaging and relevant.	3.00	1.60
9	I collaborate effectively with my peers on criminology projects and assignments.	3.09	1.54

Engagement			
No.	**Category**	**Mean**	**SD**
10	My engagement in the criminology program contributes to my overall academic success.	3.19	1.59

Criminology students report moderate class engagement, with a mean score of 3.06. However, the high standard deviation (SD = 1.69) indicates considerable variability in their levels of active involvement. While students find the course material generally interesting (mean = 3.03) and express motivation to learn (mean = 3.10), a sense of belonging within the program is lower (mean = 2.99), suggesting some students may feel disconnected. Overall, engagement in class discussions (mean = 3.16) and collaboration with peers (mean = 3.09) reflect positive social interactions, contributing to their academic success (mean = 3.19).

Figure 1. Overall Results

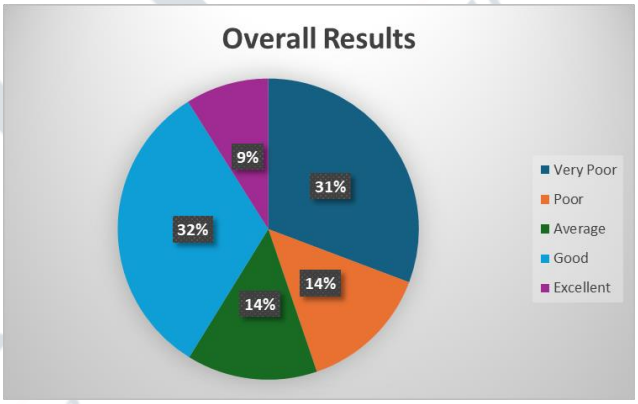

Figure 1. The overall results of the academic performance.

The academic performance data reveals a significant divide, with one-third of the students performing poorly and another doing well. Only a tiny percentage achieve excellent results. These findings highlight the need for interventions to support struggling students and sustain high achievers, aiming for a more balanced academic environment.

VII. CONCLUSIONS

1. CART Framework's Effectiveness - The Classification and Regression Trees (CART) framework demonstrated a clear and effective way to classify criminology students based on key performance indicators, providing valuable insights into their academic behaviours and needs.
2. Understanding Performance Levels - This study successfully identified distinct performance levels among students, helping educators recognise those who might need additional support and those who are excelling in their studies.

3. Impact of Key Attributes—Factors such as attendance, academic performance, behaviour, support needs, and engagement significantly influence overall student classification, highlighting the importance of a comprehensive assessment approach.
4. Importance of Tailored Interventions - By categorising students according to their performance levels, this study emphasises the need for tailored interventions that address individual students' unique areas of concern, ultimately enhancing their educational outcomes.
5. Need for Continuous Monitoring - The findings stress the importance of continuously monitoring and evaluating student performance, suggesting that regular assessments can significantly improve the effectiveness of educational support strategies.

VIII. RECOMMENDATIONS

1. **Implement Regular Assessments** - Schools should consider implementing regular assessments using the CART framework to monitor student performance and continuously adapt interventions as needed.
2. **Develop Targeted Support Programs** - Based on the classification results, educational institutions are encouraged to create targeted support programs that address the unique needs of students identified as "Very Poor" or "Poor."
3. **Enhance Student Engagement** - Strategies to boost student engagement, such as interactive learning methods and peer support systems, should be prioritised to help improve overall academic performance.
4. **Provide Training for Educators**—Educators should receive training on interpreting CART results and effectively implementing targeted interventions, ensuring they are well-equipped to support diverse student needs.
5. **Encourage Student Feedback** - Schools should establish ways to gather feedback from students regarding the support programs, allowing for adjustments based on their experiences and perceptions of effectiveness.

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