



Mathematical Models Predicting Performance in Licensure Examination of Engineering Graduates

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Abstract

The success of a tertiary educational institution's graduates on professional licensing exams is one of the most reliable indicators of the educational quality that the institution provides. For many years, the Philippines have produced many engineering graduates; however, in recent years, roughly 50% successfully passed the board exams required for licensure as engineers. The challenge that many higher educational institutions face is making all their engineering programs' passing rates improve and surpass the national passing rate. This study intended to develop a mathematical model capable of forecasting the performance of BSCE and BSME graduates from a private higher educational institution in the Philippines in the licensure examination administered by the Professional Regulation Commission (PRC). The researcher implemented a descriptive correlational research design. The graduates' academic performance and enrollment in a review center were assessed through descriptive statistics, which includes means, standard deviations, frequency, and percentages. Academic performance includes grades in courses tested by PRC in BSCE and BSME licensure examinations, which include mathematics and engineering courses. It also involves grades in purposive communication and integration courses. Pearson moment correlations, and ETA, were applied in determining the correlation of variables. Moreover, the strongest predictors of the Licensure Exam Areas 1, 2, and 3 were determined using stepwise regression, and mathematical models were developed using multiple linear regression. Mean Absolute Percentage Error (MAPE) was used to assess the models' predictive power. The result of the research is intended to serve as a helpful guide and basis for the school in preparing students for the licensure examination and a credible input for the institution's curriculum enhancement.

Keywords: mathematical model, predictor variables, mathematics, licensure examination, integration courses

Introduction

Licensure examinations serve as a crucial mechanism for assessing and assuring the quality of professionals entering the workforce, both locally and internationally, as recognized in Section 2 of Republic Act 8981. Licensure examinations are conducted by the Professional Regulation Commission (PRC), and the importance of these examinations is inferred from the legal framework that establishes the PRC and its responsibilities. The PRC is mandated to regulate and supervise the practice of various professions, ensuring that individuals who enter certain professions meet the necessary qualifications and standards. Honest and reliable licensing examinations are fundamental in establishing the competence of professionals. Consequently, universities and colleges bear a dual responsibility: to provide students with high-quality education and to meet society's demand for well-qualified professionals.

Habito (2019) wrote in the Philippine Daily Inquirer dated May 31, 2019, that in 2018, Philippines graduated approximately 50,000 engineering students, with civil engineering students being the largest cohort. However, only around 50% of them successfully passed the board exams to obtain their engineering licenses. Also, based on the licensure exam results obtained from the official PRC website (<https://www.prc.gov.ph/articles>), it can be concluded that over the last six years, the national pass rate for the civil engineering board examination has averaged approximately 40.61%; and mechanical engineering, 54.33%. This pattern of poor results is a problem that requires urgent action from academic institutions providing the programs.

This brings to light the paramount importance of licensure examination success. It is imperative for Higher Education Institutions (HEIs) to develop accurate predictors of licensure performance. Such predictive tools help identify candidates at risk

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of failing the licensure exam and enable future examinees to customize their preparation strategies. HEIs can enhance curricula for courses identified as predictors and provide additional support to students. Educators can offer guidance, tutoring, and support to improve student performance. The use of predictors in licensure examinations represents a proactive, data-driven approach to improve candidate performance and the quality of education provided by institutions. It allows for early intervention, focused preparation, and better alignment with licensure board expectations, benefiting both candidates and the professions they aim to enter.

Several studies have already explored the prediction of graduates' performance in licensure examinations, particularly for Nursing (Bautista et al., 2019), Agriculture (Nicolas, 2020), Elementary and Secondary Teacher Education (Amanonce & Maramag, 2020), BS Math (Velasco, 2022), Mechanical Engineering (Dotong et al., 2019), Civil Engineering (Vallejo, 2020), Forestry, Geology, Electrical Engineering (Callena et al., 2019), Electronics Engineering (Terano, 2018), and Agricultural Engineering (Origines & Alo, 2019).

The key to effective prediction lies in identifying and utilizing variables that are closely associated with the outcomes. Numerous studies have uncovered various variables that influence success in licensure examinations. Notably, academic performance in college has been identified as the primary indicator of success in licensure examinations for graduates of Teacher Education (Bansiong, 2019; Amanonce & Maramag; Polinar et al., 2020), Agriculture (Nicolas, 2020), Agricultural Engineering (Origines & Alo, 2019), Electronics Engineering (Terano, 2018), and Mechanical Engineering (Dotong et al., 2019). However, a study by Somosot et al. (2022) reported contrasting results for graduates of Teacher Education.

Another measure of students' achievement used by earlier academics to explore predictive variables was the terminal assessment administered before a student graduate from college in the form of a comprehensive exam for teacher education (Gabasa & Raqueno, 2021), pre-LET (Amanonce & Maramag, 2020; Fiscal & Roman, 2022), mock board for agricultural engineering (Origines & Alo, 2019), pre-board examination for electronics engineering (Terano, 2018), and institutional terminal competency assessment for nursing (Oducado et al., 2019).

Among these measures, Integration Courses are three review courses designed to assist students in their preparation for the licensure examination, specifically in the field of Engineering. The successful completion of all Integration Courses is marked by a final exam that evaluates students' development and mastery of competencies. No study or literature was found about Integration Courses' ability to forecast achievement in the licensing examination.

Entrance examination in college was also found as a significant explanatory variable of the achievement of grads in the licensing examination for Teacher Education (Somosot et al., 2022), of Agriculture (Nicolas, 2020), of Civil Engineering and Electrical Engineering (Callena et al., 2019). Specific areas identified were intelligent quotient, IQ (Bansiong, 2019) and verbal reasoning or reading comprehension capacity of students (Maaliw, 2021). The significance of verbal reasoning and reading comprehension capacity as predictors has raised questions about the predictive ability of Purposive Communication.

Furthermore, some studies discovered that review center admission/attendance (Nicolas, Polinar et al., 2020), age, sex, civil status, number of takes, period between graduation and the board examination, first or second course (Nicolas, 2020), General Scholastic Aptitude (Bansiong, 2019; Bansiong & Balagtey, 2020), curriculum (Cristobal, 2020) and high school average grade (Callena et al., 2019; Nicolas, 2020) are significant predictors as well, although some of these variables are weak determinants.

Given the concerning trend of poor outcomes in engineering licensure examinations, the contrasting claims about the predictive ability of academic performance, the knowledge gap regarding the predictive capacity of Integration Courses and Purposive Communication Course for success on the licensure examination, and the literature gap concerning the predictive ability of enrollment in review centers as a predictor of BSCE and BSME graduates' success in the licensure exam, the researcher chose to conduct a study focused on developing prediction models for the performance of BSCE and BSME graduates in the licensure examination. The research sought answers to the following specific questions.

1. Describe B.S. Civil Engineering (BSCE) and B.S. Mechanical Engineering (BSME) graduates of a private educational institution in the Philippines in terms of the performance in the licensure examination, academic performance in college, and enrollment in a review center.
2. Determine the strongest predictor for each of the Licensure Examination Area 1, 2 and 3.
3. Determine the relationship between licensure examination results of the BSCE and BSME graduates and the following factors:
 - 3.1 Academic performance:
 - 3.1.1 The strongest predictor of the Licensure Examination Area 1.
 - 3.1.2 The strongest predictor of the Licensure Examination Area 2.



- 3.1.3 The strongest predictor of the Licensure Examination Area 3.
- 3.1.4 Final grade in purposive communication.
- 3.1.5 Average grade in three integration courses.
- 3.2 Enrollment in review center.
- 4. Design mathematical models predicting performance in Licensure Examination of BSCE and BSME graduates.
- 5. Determine the prediction accuracy of the mathematical models in forecasting the performance of BSCE and BSME graduates in the licensure examination.

Literature Review

Mathematical modeling, as described by Banerjee (2022), plays an increasingly vital role across various scientific disciplines. According to Yohannes (2019), mathematical modeling transforms real-world problems into manageable mathematical formulations, utilizing theoretical and arithmetic analysis to provide insights, answers, and assistance in developing applications. Yohannes (2019) emphasizes that mathematical modeling often offers precision and a strategic approach to problem-solving, facilitating a systematic understanding of the system under simulation. It stands out as the most effective means of representation, applicable to analyzing all aspects of the physical or biological universe, including natural phenomena, technological advancements, and human interventions. This effectiveness is achieved through characterizing variables using mathematical expressions, typically through correlation (Britannica Encyclopedia, 2018).

Senapati et al. (2023) explain that a predictive mathematical model analyzes past observations to forecast future events, with past data serving as a crucial element in anticipating likely outcomes. Shankar et al. (2021) assert that an ideal model should incorporate the maximum number of relevant variables affecting study outcomes, aiming for the closest possible proximity to actual results.

There have been several attempts to develop models for predicting performance in licensure examinations (Tarun et al., 2014). Forecasting students' academic performance is crucial for anticipating potential challenges and enabling educational institutions to implement preemptive measures to avert failure (Cabanela, 2023). Delos Angeles's study (2020) aimed to identify variables predicting the performance in the licensing examination of teacher education graduates. The focus was on evaluating the quality of process variables, such as instruction and curriculum, highlighting the crucial role of predictors in forecasting performance.

One of the significant impacts of mathematical modeling is its ability to identify variables influencing success in licensure examinations and predict performance. Rustia et al.'s (2018) model, for example, has the capability to pinpoint students at risk of failing the Licensure Examination for Teachers. It is recommended to give priority to these students during their mock board review, thereby increasing their likelihood of passing the examination. This not only aids individual students but also plays a role in elevating the institution's overall pass rate in the Licensure Examination for Teachers, offering potential benefits during the accreditation process.

Moreover, the prediction models by Gabasa & Raqueño (2021) identified comprehensive exams as strong predictors of graduates' licensing success, leading to the suggestion that the college conducts more intensive practice with comprehensive examinations. The model established by Terano (2018) emphasized the significance of academic achievements and pre-board examination results as indicators for the success of BSECE graduates in the electronics engineering board exam. The interpretation of academic performance is contingent on the indicators employed to measure it, as academic achievement encompasses a broad spectrum of educational outcomes (Steinmayr et al., 2020). This underscores the recommendation that the institution undertake intensive evaluations of academic courses and regularly improve its curriculum.

Methods

A descriptive correlational research design was employed in this study. The descriptive correlational method was found appropriate for the study because there is an exploration of the engineering graduates' academic performance. In addition, the problem calls for identifying the characteristics, frequencies, and trends necessary in developing a mathematical model for predicting achievement of the BSCE and BSME graduates in the licensure examination.

The data were gathered from a private higher educational institution in the Philippines: 204 graduates of Bachelor of Science in Mechanical Engineering (BSME), and 206 graduates of Bachelor of Science in Civil Engineering (BSCE). The graduates took the professional licensure examination from September 2017 to April 2023.

The researcher divided the obtained data into 80% training set and 20% testing set. According to Gholamy et al. (2018) to avoid overfitting, it is important to separate data into training and testing sets. He also mentioned that empirical studies show the best result at 70/30 and 80/20 relation of training and testing sets.

Cleaning of data was done prior to data analysis. All six assumptions of Multiple Linear Regression and Stepwise Regression were satisfied. The assumptions include type of data, linearity, residual independence, normality, absence of multicollinearity and homoscedasticity.

In analyzing the graduate's performance in the board examination and academic performance in college, frequency and percentage was utilized as well as mean and standard deviation. To define the graduates' average performance for each variable, the mean was applied and to determine homogeneity/heterogeneity, the standard deviation was used. Frequency and percentage were employed to know the graduates' performance in the licensure examination, and frequency of graduates' enrollment in review center.

The Pearson moment correlation was employed for interval-to-interval correlation. Additionally, as in the research of Lumagsao & Delloso (2019), for nominal-to-interval, the association was determined using the eta value. Moreover, to forecast the licensing examination achievement of the graduates, multiple linear regressions was employed. Stepwise regression, on the other hand, was utilized to identify the strongest predictor for each licensure examination areas. And to evaluate the mathematical model developed through multiple linear regression, this study employed Mean Absolute Percentage Error (MAPE).

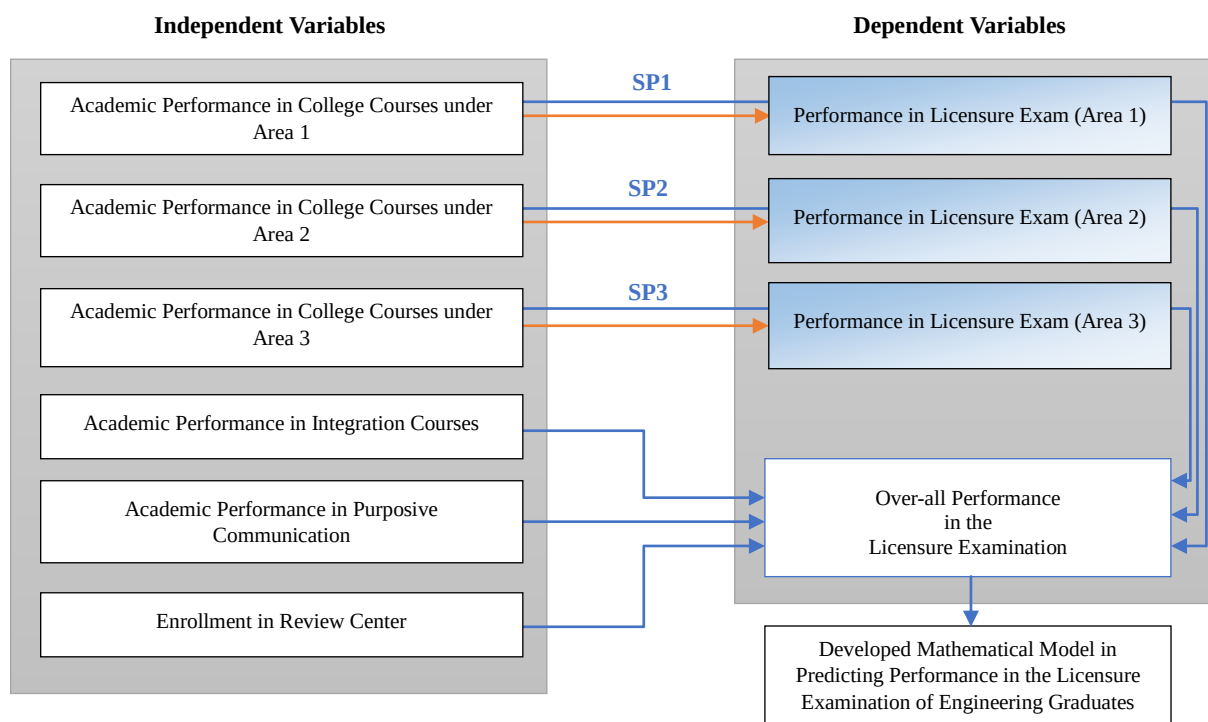


Figure 1. Research Paradigm

- SP1 – The strongest predictor of performance in the Licensure Examination Area 1,
- SP2 – The strongest predictor of performance in the Licensure Examination Area 2,
- SP3 – The strongest predictor of performance in the Licensure Examination Area 3

Figure 1 encapsulates the framework of the present research. It depicts the procedure involving the variables of this research. The first frame indicates the independent variables, which were assumed to exert a significant impact on the dependent variables. The next part of the framework pertains to the predicted variables, which consist of the graduates' performance in the three distinct licensure examination areas and the overall performance in the form of a general average rating. Specifically, the first Civil Engineering Licensure Examination area is about Mathematics, Surveying, Principles of Transportation and Highway Engineering, and Construction Management and Methods. The second area is centered around Hydraulics and Geotechnical Engineering, while the third area deals with Principles of Structural Analysis and Design. In the mechanical engineering licensure exam, tests are categorized also into three main areas. The first area comprises Industrial and Power Plant Engineering, area 2 encompasses Mathematics, Engineering Economics, and Basic Engineering Services, and the third area includes Machine Design Materials and Shop Practice courses. The last frame indicates the result of the research, which is the prediction model each for BSCE and BSME programs that predicts how engineering graduates will do on the licensure to get licensed.



The dependent and independent variables were classified according to their type of data. The table below presents the research variables, their description and how they are coded in SPSS.

Table 1. The Research Variables and their Description

Factors	Description	Values	Descriptors	Numerical Values
Performance In Licensure Examination	actual rating in the licensure exam	0 to 100	Excellent Very Good Good Fair Passing Failed	94-100 88-93.99 82-87.99 76-81.99 70-75.99 69.99-below
Academic Performance	final grade in mathematics and engineering courses tested in the licensure exam final grade in purposive communication course average grade in three integration courses	1.00 to 3.00	Excellent Superior Meritorious Very Good Good Very Satisfactory Satisfactory Fair Passing	1.13-1.00 1.38-1.14 1.63-1.39 1.88-1.64 2.13-1.89 2.38-2.14 2.63-2.39 2.88-2.64 3.00-2.89
Enrollment In Review Center	enrollment in any review center after college	Yes, No	No Yes	0 1

Results and Discussions

Based on the interpretation and analysis of the data gathered, the following summary of findings is enumerated:

1. In the CELE, the majority of BSCE graduates fell into the fair category, with the best performance observed in Area 2, having the highest mean, and the least performance in Area 3, marked by the lowest mean scores. On the other hand, among the areas in the Mechanical Engineering Licensure Examination, Area 2 recorded the highest mean score, falling within the fair category, followed by Area 1 and then Area 3. The majority of BSME graduates were classified in the passing category.

Table 2 shows that, on average, BSCE and BSME graduates who passed their respective Licensure Examination Areas scored higher compared to those who did not pass. Furthermore, the overall average rating reveals a distinct contrast between those who passed and those who failed, with passing BSCE and BSME graduates attaining notably higher average scores. Across both CELE and MELE, a consistent trend emerges, indicating that graduates who passed the examination scored significantly higher than their peers who failed in all areas and the general average rating.

Table 2. Summary of Passed and Failed Performance in the Licensure Examination

Licensure Examination		Mean (Passed)	Mean (Failed)
Civil Engineering Licensure Exam (CELE)	Area 1	78.02	69.42
	Area 2	83.77	67.74
	Area 3	74.92	51.84
	Gen. Ave.	78.66	62.57
Mechanical Engineering Licensure Examination (MELE)	Area 1	78.67	60.63
	Area 2	78.15	64.96
	Area 3	74.42	57.88
	Gen. Ave.	77.21	61.32

When assessing academic performance in college mathematics courses, a diverse range was observed. The majority of BSCE graduates' performance was distributed across the passing to very good range, with the greatest number falling into the very satisfactory category. Moreover, the majority of BSME graduates' performance spanned the passing to good range, with the greatest number in the 'satisfactory' category. This also indicates that, in both BSCE and BSME programs, a low percentage of graduates achieved an excellent grade in mathematics courses. There was a consistent trend of best performance in Advanced



Engineering Mathematics (including Numerical Methods for BSCE) and least performance in Calculus 2 compared to other mathematics courses for both programs.

In various engineering courses, the majority of BSCE graduates obtained a good rating, while most BSME graduates achieved a very satisfactory rating. BSCE graduates performed best in Hydrology, followed by Geology, and then Construction Materials and Testing. On the other hand, BSME graduates excelled in Manufacturing & Industrial Processes with Plant Visits, followed by ME Law, Ethics, Codes, and Standards, and then Machine Shop Theory. Nevertheless, a majority of both BSCE and BSME graduates demonstrated good performance in Integration Courses.

Regarding Purposive Communication, the academic performance of BSCE graduates is generally rated as very good, whereas BSME graduates' performance is generally rated as good. Additionally, most of these graduates enrolled in review centers, recognizing the importance of these centers in enhancing their preparation for the licensing examination.

2. As exhibited in Table 3, for the BSCE program, academic performance in Calculus 1, Geology, and Principles of Reinforced/Prestressed Concrete were found to be the strongest predictors of the Civil Engineering Licensure Examination Areas 1, 2, and 3, respectively, based on stepwise regression. Moreover, the strongest predictors of the Mechanical Engineering Licensure Examination in Areas 1, 2, and 3 are the academic performance in Heat Transfer, Calculus-Based Physics, and Materials Science and Engineering for ME, respectively, according to stepwise regression.

Notably, these courses displayed r-squared values ranging from .025 to .421 with significant F-changes. Although this finding suggests that the performance of graduates in the corresponding college courses explains less than 50% of the variability in the performance in the Licensure Examination Areas, these results underscore the significant role of these courses in explaining variance in the licensing examination areas.

Table 3. Strongest Predictors (SP) of the Licensure Examination Areas

Licensure Examination (DV)		College Courses (IV)	R	r ²	F-change	Sig. F Change
Civil Engineering (CELE)	Area 1	Calculus 1	.545	.297	4.636	<.05
	Area 2	Geology	.159	.025	4.133	<.05
	Area 3	Principles of Reinforced/Prestressed Concrete	.314	.099	4.041	<.05
Mechanical Engineering (MELE)	Area 1	Heat Transfer	.445	.198	6.528	<.05
	Area 2	Calculus-Based Physics	.649	.421	8.498	<.05
	Area 3	Mat Sci & Eng'g for ME	.355	.126	4.502	<.05

3. All three strongest predictors of the areas of CELE, along with academic performance in, integration courses, purposive communication, and enrollment in review centers, were found to have statistically significant positive correlations with the graduates' performance in the Civil Engineering Licensure Examination. Furthermore, the strongest predictors of the MELE in Areas 1, 2, and 3, in addition to purposive communication, and integration courses, were found to have statistically significant positive correlations with the Mechanical Engineering Licensure Examination.

Table 4. Relationship between Licensure Examination Performance and Academic Performance

Licensure Examination	College Courses	R	VI	p-value	Remarks
Civil Engineering (CELE)	Calculus 1 (SP1)	.574	Substantial	<.05	S
	Geology (SP2)	.275	Low	<.05	S
	Princ of Reinforced/Prestressed Concrete (SP3)	.249	Low	<.05	S
	Purposive Communication	.151	Very Low	<.05	S
	Integration Course	.160	Very Low	<.05	S
Mechanical Engineering (MELE)	Heat Transfer (SP1)	.471	Substantial	<.05	S
	Calculus-Based Physics (SP2)	.540	Substantial	<.05	S
	Mat Sci & Eng'g for ME (SP3)	.470	Substantial	<.05	S
	Purposive Communication	.449	Substantial	<.05	S
	Integration Course	.573	Substantial	<.05	S

Correlation was based on the contrasting rating scales used in college courses and licensure examinations. There is high positive correlation when grade in college courses gets closer to 1.00 which indicates better performance, as the licensure examination rating gets closer to 100 signifying better performance also.

Table 5 reveals an association between enrolling in a review center before taking the board exam and performance in the CELE as specified by the obtained eta value ($\eta = 0.290$, $p < .001$ based on ANOVA). The finding, however, is different with the BS Mechanical Engineering graduates, the association between enrolling in a review center and licensure examination performance in terms of rating was found to be very weak and not significant.

Table 5. Relationship between Licensure Examination Performance and Enrollment in Review Center

	Program	η	*p-value	Remarks
Enrollment in Review Center	BSCE	.290	<.05	S
	BSME	.066	.405	NS

* based on ANOVA

4. For BSCE graduates: Calculus 1, Principle of Reinforced/Prestressed Concrete, and Enrollment in a Review Center were found to be significant predictors of the performance of graduates in the Civil Engineering Licensure Examination (CELE). While the predictive ability of these three factors is relatively small, as evidenced by the r-squared value of 0.420, signifying that these factors explain approximately 42% of the variability in BSCE graduates' performance in the Licensure Examination, it remains statistically significant. The developed mathematical model for the BSCE program of a private higher educational institution in the Philippines suggests that, for a grade of x_1 in Calculus 1, a grade of x_2 in the Principle of Reinforced/Prestressed Concrete, and a binary response of x_3 in Enrollment in a Review Center, the predicted performance in CELE can be computed as: $\hat{y} = 86.946 - 7.634x_1 - 1.824x_2 - 11.371x_3$.

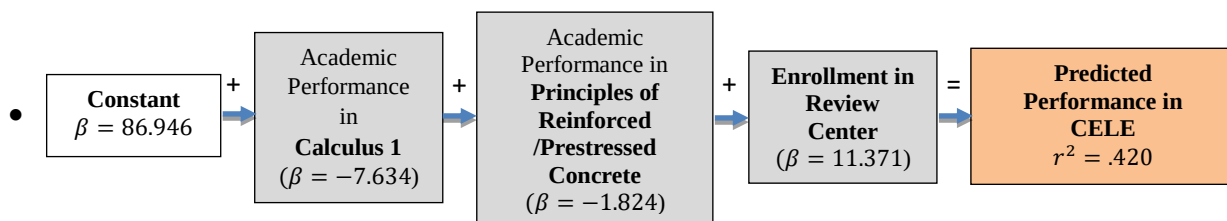


Figure 2. Mathematical Model for BSCE Program

For BSME graduates: Integration Courses, Calculus-Based Physics, and Purposive Communications were found to be significant predictors of BSME graduates' performance in the Mechanical Engineering Licensure Examination (MELE). While the predictive ability of these three factors is relatively small, as evidenced by the r-squared value of 0.477, signifying that these factors explain approximately 47.7% of the variability in BSME graduates' performance in the Licensure Examination, it remains statistically significant. The developed mathematical model for the BSME program of a private higher educational institution in the Philippines suggests that, for a grade of x_1 in Integration Courses, a grade of x_2 in Calculus-Based Physics, and a grade of x_3 in Purposive Communication, the predicted performance in MELE can be computed as: $\hat{y} = 106.079 - 5.360x_1 - 5.772x_2 - 2.965x_3$

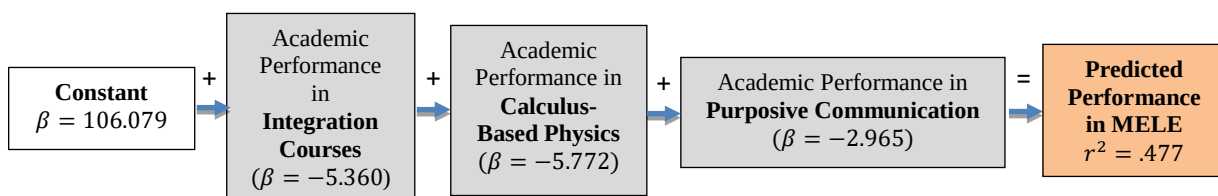


Figure 3. Mathematical Model for BSME Program

5. Table 6 presents MAPE results for the BSCE and BSME mathematical models developed using multiple linear regression applied to both training and testing sets. The low MAPE values of 6.47, 9.1, 6.37 and 13.2 of the training and testing



sets suggest that the mathematical model's predictions are close to the actual values, indicating a good to very good forecasting performance. The higher MAPE values for the testing set, matched to the training set, implies that the model's performance might have slightly deteriorated when applied to unseen data.

Furthermore, in both cases, the models perform better in predicting students who passed compared to those who failed. MAPE result of 23.8 and 26.6 indicates fairly good mathematical model's predictions.

Table 6. MAPE for the Mathematical Models

Program	Set	MAPE Result	Outcome	MAPE Result
BSCE	Training Set	6.47		
	Testing Set	9.1	Passed	7.4
			Failed	23.8
BSME	Training Set	6.37		
	Testing Set	13.2	Passed	6.4
			Failed	26.6

Conclusions

In light of study's finding, the subsequent conclusions were formulated:

1. In both Civil Engineering Licensure Examination (CELE) and Mechanical Engineering Licensure Examination (MELE), a consistent pattern emerges graduates who successfully passed the examination achieved significantly higher scores than those who did not, across all specific areas and in the general average rating. This analysis indicates that performance in specific areas is correlated with the overall success of graduates in these licensure examinations. Graduates need to perform well in all areas to pass the exam.
2. The strongest predictors for Civil Engineering Licensure Examination Area 1, 2, and 3 based on stepwise regression are Calculus 1, Geology, and Principles of Reinforced/Prestressed Concrete, respectively. Similarly, for Mechanical Engineering Licensure Examination Area 1, 2, and 3, the strongest predictors based on stepwise regression are Heat Transfer, Calculus-Based Physics, and Materials Science and Engineering.
3. The strongest predictors for their respective licensure examination areas were significantly and mostly substantially correlated with the general average rating of the licensure examination.
4. Mathematical model predicting performance of BSCE graduates from a private higher educational institution in the Philippines in the Civil Engineering Licensure Examination:

$$\hat{y} = 86.946 - 7.634x_1 - 1.824x_2 - 11.371x_3$$

(Where: x_1 - grade in Calculus 1, x_2 - grade in Principle of Reinforced/Prestressed Concrete, and x_3 - a binary outcome in Enrollment in a Review Center.)

Mathematical model predicting performance of BSME graduates from a private higher educational institution in the Philippines in the Mechanical Engineering Licensure Examination:

$$\hat{y} = 106.079 - 5.360x_1 - 5.772x_2 - 2.965x_3$$

(Where: x_1 - grade in Integration Courses, x_2 - grade in Calculus-Based Physics, and x_3 - grade in Purposive Communication).

5. The developed mathematical models can forecast passing performance of BSCE and BSME graduates in the licensure examination with high prediction accuracy. However, the mathematical models failed to provide high prediction accuracy in forecasting failing performance in the licensure examination of the BSCE and BSME graduates.

Conflict of Interest

Authors have no conflict of interest to declare.

Author Contribution Statement:

C.C. contributed to the study conception and design, data collection, processing, analysis and interpretation of results, and manuscript writing. M.G. contributed to the critical revision or editing of the article, gave final approval for the version to be published, and provided supervision.



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