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Determinants of performance in the board examination for Mechanical Engineering graduates of the Nueva Vizcaya State University, Bambang campus

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ABSTRACT

A culture of excellence and quality should always incorporate continuous improvement. Institutions of higher learning are the spearheads of creative minds and improve the capability and caliber of the professionals and leaders resulting from the confluence of academic and industrial relationships. A yardstick called board examination is administered to engineering graduates by the Professional Regulations Commission (PRC) to produce licensed engineers in the Philippines. Considering this, the research aims to investigate the determinants of board examination performance for Mechanical Engineering graduates of the Nueva Vizcaya State University, Bambang Campus. The data were gathered through surveys and interviews of mechanical engineering graduates and faculty members involved in board exam preparation programs. To analyze the performance details of the board examination in the Mechanical Engineering program of the Nueva Vizcaya State University, various quantitative methods such as t-test, correlation analysis, logistic linear regression, and path analysis are utilized to test the significance level between 2011 - 2015 and 2016 - 2020, who took the board examination; establish if there is any association between board examination and academic performance, and predict subject areas that affect most the performance in the board examination as well to create a mathematical prediction model in this aspect. The findings of this study would serve as a guide and an eye-opener for engineering learning institutions in determining effective strategies to improve the board exam performance of mechanical engineering graduates and as well enhance the quality of mechanical engineering education.

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INTRODUCTION

Engineering students' demographics vary greatly from various academic backgrounds compared to learners in other disciplines. According to a set of program outcomes in the Bachelor of Science in Mechanical Engineering, as described in the CHED Memorandum Order (CMO) No. 97 series of 2017, the undergraduate student must be able to employ scientific and mathematical skills to deal with engineering issues; to plan, organize, and carry out experiments; to evaluate, interpret, and assess data; to create a system, part, or procedure that satisfies requirements while adhering to acceptable standards; serve in diverse and multifaceted teams; acknowledge, create, and handle intricate issues in mechanical engineering; comprehend ethical and professional accountability; express properly; comprehend the implications of mechanical engineering remedies in an international, financial, ecological, and social setting; acknowledge the need for and pursue continuous improvement; be aware of current issues; employ the methods, abilities, and cutting-edge engineering tools essential for mechanical engineering application; and, finally, comprehend the concepts of engineering and leadership and to oversee projects in a diverse setting (Commission on Higher Education, 2017). These program outcomes are expected to be fulfilled or satisfied by any student, who is taking up the course Bachelor of Science in Mechanical Engineering (BSME) program.

Before someone can practice engineering, they must obtain an official registration or license from the Professional Regulation Commission (PRC) after completing the said engineering course in any state university and college (SUC). The Commission is tasked with overseeing, carrying out, and upholding national legislation about the regulatory and licensing processes of different professions throughout the nation. Every candidate seeking to register to engage in engineering practice must have a satisfactory rating in the board exam. A similar law was passed in the United States that seeks to improve the quality of graduates. The goal of this law is to use licensure examinations to hold higher education institutions accountable for the quality of graduates' preparation and licensing (Raymond,1999). Hence, according to Hedderick (2009), universities use the results of licensing and certification tests to gauge how well their curriculum are doing in terms of hands-on evaluation in the field. Stewart (2004) bolsters this assertion by stating that colleges and universities view passing the licensing exam as a key performance indicator for evaluating the efficacy of the curriculum. To determine the possible factors that influence passing rates on the national licensure examination, results on the test are tracked in conjunction with mock board results from the final year of high school. Because engineers play such important roles in the global community, most governments are now focusing on licensing this profession. The goal of certification and licensure, according to the American Educational Research Association, American Psychological Association, and National Council on Measurement in Education, is to safeguard the public by guaranteeing that those who engage in a field possess a minimum level of competence. Most states also mandate that a candidate for licensing hold a degree from an engineering program approved by ABET, Inc.'s Engineering Accreditation Commission (EAC-ABET).

Nueva Vizcaya State University, a level four (IV) accredited institution in Region 2 is confronted with an ongoing situation in which there is a requirement to maintain the programs' growing desire for excellence offered by the school, particularly those with board courses. Currently, the College of Engineering-Bambang Campus provides an undergrad degree in Bachelor of Science in Mechanical Engineering and it is continually striving for excellent performance in the board exams. This is crucial in the Philippines as they serve as a regulatory requirement to obtain a license as a Registered Mechanical Engineer (RMEE) and upgrade it to Professional Mechanical Engineer (PME) before rendering mechanical engineering services such as engineering design, consultation, supervision in the erection, installation, alteration, testing, and commissioning of mechanical equipment. This license is essential for practicing mechanical engineering professionally in the country as provided in Republic Act No. 8495 also known as "An Act Regulating the Practice of Mechanical Engineering in the Philippines" based on the Code of Ethics of the Philippine Society of Mechanical Engineers (PSME). The Commission on Higher Education (CHED) Memorandum Order (CMO) sets the standards and guidelines for programs in Mechanical Engineering offered by educational institutions in the Philippines. The CMO outlines the program outcomes that students need to achieve during their education to qualify for the board exams. These program outcomes are important in the context of board exams because they reflect the necessary knowledge and skills that a mechanical engineer should possess to be competent in the field. The board exams assess the competency of candidates in these program outcomes and their application

in practical engineering situations. Program outcomes such as engineering analysis, design, and practical skills are assessed in the board exams to ensure that candidates have a comprehensive understanding of the principles and practices of mechanical engineering. The exams test the candidate's ability to solve engineering problems, make informed design decisions, and apply theoretical knowledge in real-world scenarios. By achieving the program outcomes, candidates demonstrate their competence and readiness to practice as mechanical engineers. The board exams validate their understanding and application of mechanical engineering concepts, ensuring that licensed professionals meet the required standards for public safety and welfare.

As strategies, the board examination reviews and adoption the subject Course Audit also known as Review Subjects. The review takers are trained analytically in the subject areas of Mathematics, Engineering Economics, and Basic Engineering Sciences (MEEBES); Power and Industrial Plant Engineering (PIPE); Machine Design, and Shop Practice (MDSP) in preparation for the actual board examination. National data indicates that the percentage of candidates passing the Mechanical Engineering board exam varied between 54.77 and 77.06 percent between March 2016 and February 2020. This data supports the assertion made by numerous alums that board exams for engineering specializations are typically more difficult due to milestones set over time. As cited in the PRC board result (2015) website, "*it seems that 4 years of education does not always reflect on a college diploma, but the Professional Identification Card given by professional regulating agencies like Professional Regulation Commission (PRC).*" However, the Mechanical Engineering graduates of the Nueva Vizcaya State University maintain a satisfactory board exam rating and surpass the national passing rate.

In light of this, exploring the determinants of performance in the Mechanical Engineering board examination is the point of interest that needs to be answered in this study. The findings of this study will help university administrators, particularly those in the College of Engineering to develop and implement guidelines relating to future board examinations for Mechanical Engineering graduates, fostering and synchronizing the outcomes-based curriculum with the specifications of the board exam. The academic capabilities of engineering students both in general and professional subjects, which may have an impact on the board examination, will also be extensively disclosed to the faculty members.

OBJECTIVES OF THE STUDY

The main goal of the research is to investigate the determinants of board examination performance for Mechanical Engineering graduates of the Nueva Vizcaya State University, Bambang Campus.

Specifically, it aims to attain the following research objectives:

1. compare the significance level in the board examination performance of graduates in the Mechanical Engineering program between 2011 to 2015 and 2016 to 2020;
2. evaluate the level of academic outcome of the Mechanical Engineering graduates from 2011 - 2020 along with Machine Design, Materials and Shop Practice (MDSP); Mathematics, Engineering Economics, and Basic Engineering Sciences (MEEBES) and Power and Industrial Plant Engineering (PIPE)
3. test the association between the graduates' level of academic outcome and level of board examination performance in the Mechanical Engineering program;
4. explore the subject clusters that best predict the board examination performance of graduates in the Mechanical Engineering program;
5. develop a mathematical model to forecast the board examination performance of graduates in the Mechanical Engineering program;
6. scout the facilitating factors that contribute to the success of the Mechanical Engineering board examination performance.

MATERIALS AND METHODS

A quantitative research design was employed since it systematically investigates occurrences by collecting quantifiable data and applying mathematical and statistical methods. Using a sampling technique, quantitative research gathers data and information from current populations. Larger samples representative of the total population were used to gather data utilizing an organized methodology. The study's samples came from Nueva Vizcaya State University graduates who earned a Bachelor of Science in Mechanical Engineering and took the PRC board examinations from the year 2011 to 2020. The researchers used documentary information or data from the board examinations from the Professional Regulations Commission (PRC) as the main source of data. Only graduates who took the board examination for the first time were included in the study. Outcomes attained from the analysis and interpretation of these data are unbiased, statistical, and logical. The descriptive-correlational research method and trend analysis were employed in this study. According to Shuttleworth (2008), descriptive research is a methodological strategy that includes observing and describing the performance of a subject without controlling it by any means or methods. It is a valid system for researching specific subjects. Correlational research investigates one or more variables of a group to determine the extent of association between variables. Descriptive and correlational research investigate variable factors in their normal situations and it does not incorporate researcher-imposed treatment. Correlational research presents the relationships among factors by such strategies as cross-tabulation and correlations. The core purpose of correlational research is to investigate associations or relationships between factors, and on the off chance that a relationship exists, a regression equation is to be determined that will be utilized to make a forecast or predictions for a population.

Different statistical techniques were applied per research objective to give relevant results and insights. Here, the first objective is evaluated using an independent t-test since its use is to compare if there is a significant difference between the two groups of interest, particularly those who took the board exam from S.Y. 2011-2015 as group 1 and S.Y. 2016-2020 as group 2. After that, a comparison between the default probability value or p-value of 0.05 or 5% with the computed p-value, which could be obtained from statistical software like SPSS or Excel to see if there is indeed a significant difference (i.e. p-value @ 0.05 > p-value computed) or not significant (i.e. p-value @ 0.05 < p-value computed) between the two groups. Meanwhile, the second objective is evaluated using the Mean or simply the average and standard deviation in the three-board exam subject areas from S.Y. 2011-2020. The term standard deviation tells how dispersed or spread out the data of the board exam scores per subject area from the mean or average board exam score. This means that the lower the standard deviation, the board exam scores per subject area are nearly close to the mean or average score. As for the third and fourth objectives, correlation analysis along with regression analysis was utilized to test the relationship between academic performance and board examination performance of the Mechanical Engineering graduates in S.Y. 2011 – 2020 using the Pearson correlation coefficient (R), a measure of the strength of the linear relationship which is obtained in regression analysis. The idea behind regression analysis is to predict or forecast if there is a direct or inverse linear relationship between these two variables through a graphical solution (i.e., a line graph pointing to the right or the left or a horizontal line) or analytical solution via the Pearson correlation coefficient (R) (i.e. either positive values to show a direct relationship; negative values to show an inverse relationship or zero value to show no relationship at all). For the fifth objective, a form of multiple regression analysis called path analysis was developed, which is a graphical model utilized to evaluate the impact of three or more variables acting on a specified outcome (effect) via multiple causal (cause) pathways between nodes. To construct the path model, the names of the variables are written, and the arrows are drawn from each variable going to any other variables which is believed to have an effect. Predicting the causal relationships implied by the hypothesis, an input path map is created in advance to help direct and organize the analysis. A statistical analysis's output path diagram displays the findings and depicts the analysis's outcomes. For the last objective, an unstructured interview is implemented to explore the facilitating factors that affect the success of the result of the Mechanical Engineering board examination based on their academic experience and point of view.

RESULTS AND DISCUSSION

The performance of graduates from Nueva Vizcaya State University in the Mechanical Engineering board examination as shown in Table 1 describes the data of first takers from 2011 to 2015. No graduates took the examination during the March 2011 mechanical engineering board examination. A total of 141 graduates took the examination and 109 of them luckily passed with a 77% passing percentage. Moreover, of the said total, 12.06% in September 2011; 1.42% in March 2012; 8.51% in September 2012; 2.84% in March 2013; 20.57% in September 2013; 3.55 % in March 2014; 25.53% in October 2014; 6.38% in March 2015; and 19.15% in September 2015.

Table 1. Performance of NVSU graduates in the Mechanical Engineering Board Examinations for first takers from 2011 - 2015

Month	Year	No. of first-taker examinees	Percentage for the number of examinees (%)	No. of passers for first takers	Percentage passing for first takers (%)
March	2011	No examinees	N/A	N/A	N/A
September	2011	17	12.06	7	41.18
March	2012	2	1.42	2	100.00
September	2012	12	8.51	10	83.33
March	2013	4	2.84	4	100.00
September	2013	29	20.57	25	86.21
March	2014	5	3.55	4	80.00
October	2014	36	25.53	34	94.44
March	2015	9	6.38	7	77.78
September	2015	27	19.15	16	59.26
	Total	141			

Other pertinent data related to the performance of graduates from Nueva Vizcaya State University in the Mechanical Engineering board examination is shown in Table 2 from 2016 to 2020. No graduates took the August 2020 Mechanical Engineering Board Examination and onward due to health crises brought by the COVID-19 pandemic. A total of 179 graduates took the examination and 137 of them luckily passed with a 76.54% passing percentage. Moreover, of the said total: 5.59% took the examination in March 2016; 17.32% in September 2016; 1.68% in March 2017; 23.46% in September 2017; 0.56% in February 2018; 15.64% in August 2018; 6.14% in February 2019; 6.70% in August 2019; and 22.9% in February 2020.

Table 2. Performance of NVSU graduates in the Mechanical Engineering Board Examinations for first takers from 2016 - 2020

Month	Year	No. of first-taker examinees	Percentage for the number of examinees (%)	No. of Passers for first takers	Percentage passing for first takers (%)
March	2016	10	5.59	7	70.00
September	2016	31	17.32	23	74.19
March	2017	3	1.68	3	100.00
September	2017	42	23.46	37	88.10
February	2018	1	0.56	0	0
August	2018	28	15.64	22	78.57
February	2019	11	6.14	8	72.73
August	2020	12	6.70	11	91.67
February	2020	41	22.90	26	63.41
	Total	179			

To answer the first objective, a statistical tool called an *independent t-test* was employed to show the significance level in the board examination performance of graduates in the Mechanical Engineering program between 2011 to 2015 and 2016 to 2020. The corresponding result is described in Table 3, where the control and experimental groups with the given t-critical value of 1.746 are being analyzed.

Table 3. Mean and t-ratio of the two groups of Mechanical Engineering board examinees

Mean		Computed	Computed	Remarks
Control	Experimental	t-value	p-value	
80.244	70.96	0.7984	0.22	Not Significant

t - critical =1.746

Since the computed t-value of 0.7984 is less than the t-critical value of 1.746 with a corresponding p-value of 0.22, there is evidence to conclude that there is no significant difference between the board exam results of graduates of S.Y. 2011 to 2015 and graduates of S.Y. 2016 to 2020. However, several factors have been identified that affect performance on the board examination just like academic performance in coursework wherein Gibson & O'Malley (2016) and Johnson (2015) have mentioned that grades earned in coursework are positively related to performance on licensure exams. Another factor is study habits and motivation. Pintrich & DeGroot (1990) and Pekrun et al. (2009) explained that graduates who have developed effective study habits and maintain high levels of motivation tend to perform better in the board examinations. Test-taking skills and strategies must also be considered. Graduates who have developed effective test-taking skills and strategies, such as time management and test anxiety management, tend to perform better in board exams (Cizek, 2004; Fitzgerald & Williams, 2011). Studies showed also that clinical experience could be a contributor, wherein graduates who have had more clinical experience tend to perform better in board exams (Hemphill, 2018; Vonderheide, et al., 2017). Meanwhile, graduates who demonstrate high levels of professional behaviors and attitudes tend to perform better on licensure exams (Murphy, 2019; Oermann, 2019). Lastly, the availability and quality of pre-licensure preparation programs also play a significant role in students' performance in board examinations (Jiang, Li, & Sun, 2016; Khan, 2017).

To answer the second objective, computation of the mean and standard deviation is utilized to evaluate the level of academic performance of the Mechanical Engineering graduates from S.Y. 2011 - 2020 along with Machine Design, Materials and Shop Practice (MDSP); Mathematics, Engineering Economics, and Basic Engineering Sciences (MEEBES) and Power and Industrial Plant Engineering (PIPE).

Table 4. Summary of mean and standard deviation of the academic performance of Mechanical Engineering graduates from 2011 – 2020

Subject Clusters	Mean	Standard Deviation	Qualitative Description
MEEBES	2.667	0.278	Satisfactory
PIPE	2.770	0.223	Satisfactory
MDSP	2.559	0.219	Satisfactory
GWA	2.658	0.231	Satisfactory

where:

Point System	Percentage System	Qualitative Description
1.00	97 - 100	Outstanding
1.25	94 - 96	Very Satisfactory
1.50	91 - 93	Very Satisfactory
1.75	88 – 90	Very Satisfactory
2.00	85 – 87	Very Satisfactory
2.25	82 – 84	Satisfactory
2.50	79 – 81	Satisfactory
2.75	76 – 78	Satisfactory
3.00	75	Passing

A summary of mean and standard deviation on the academic outcome of graduates from 2011 - 2020 along with Machine Design, Materials and Shop Practice (MDSP); Mathematics, Engineering Economics, and Basic Engineering Sciences (MEEBES) and Power and Industrial Plant Engineering (PIPE) with the corresponding general weighted average (GWA) is presented in Table 4. The academic performance of the graduates in Machine Design, Materials and Shop Practice (MDSP); Mathematics, Engineering Economics, and Basic Engineering Sciences (MEEBES), and Power and Industrial Plant Engineering (PIPE) has a mean of 2.559, 2.667, and 2.700 respectively with a general weighted average is 2.658 can be described as satisfactory. From the data presented, Machine Design, Materials, and Shop Practice (MDSP) cluster has the lowest mean, followed by the Mathematics, Engineering Economics, and Basic Engineering Sciences (MEEBES). In contrast, Power and Industrial Plant Engineering (PIPE) has the highest average, which indicates that among the three subject clusters, students find it more difficult to have a better or passing grade in PIPE. Moreover, the table shows the samples' grades in Mathematics, Engineering Economics, and Basic Engineering Sciences (MEEBES), Power and Industrial Plant Engineering (PIPE), and Machine Design, Materials, and Shop Practice (MDSP) as well as their General Weighted Average were close to 2.75 since the computed standard deviation is 0.20. Dotong (2019) claimed that for average engineering students, having an average academic rating of 2.836 is considered normal. Engineering students believe that their grades are not the basis of their logical capacity because exams only measure a portion of becoming successful engineers.

To answer the third objective, a correlation analysis is employed to test the association between academic outcome and board examination performance of the Mechanical Engineering graduates of S.Y. 2011 - 2020 along Machine Design, Materials and Shop Practice (MDSP); Mathematics, Engineering Economics, and Basic Engineering Sciences (MEEBES) and Power and Industrial Plant Engineering (PIPE) is performed. It can be inferred from the table below that there is a significant association between the academic outcome and board exam performance of Mechanical Engineering graduates as indicated by the p-value of less than 0.05.

Table 5. The Pearson correlation coefficients between academic and board exam performance of the Mechanical Engineering graduates in 2011-2020

Academic Performance	Board Examination Performance							
	MEEBES		PIPE		MDSP		Rating	
	R	p-value	R	p-value	R	p-value	R	p-value
MEEBES	-0.412	0.000	-0.370	0.000	-0.352	0.000	-0.500	0.000
PIPE	-0.301	0.001	-0.399	0.000	-0.504	0.000	-0.524	0.000
MDSP	-0.278	0.002	-0.355	0.000	-0.468	0.000	-0.477	0.000
GWA	-0.383	0.000	-0.404	0.000	-0.448	0.000	-0.541	0.000

Results showed that the MEEBES cluster has a computed Pearson correlation coefficient (R) of -0.500 when correlated with their board rating. The PIPE and MDSP have a computed R-value of -0.524 and -0.477 respectively.

The academic performance indicates a marked correlation with the licensure examination performance. The negative result of the computed R-value signifies that there is a negative correlation or inverse relationship between academic performance and licensure examination performance. This is due to the Quality Point Index (QPI) or pointing system used by the Nueva Vizcaya State University as a basis for giving grades to students. Results signify that with higher academic ratings, there is a chance to achieve better results in board exams.

To attain the fourth objective, a linear regression analysis was utilized to analyze the subject clusters that best predict the board examination performance of graduates in the Mechanical Engineering program.

Table 6. Model summary of the predictors in the Mechanical Engineering board exam.

Model	Unstandardized Coefficients (B)	Standard Error	Coefficients of Standardized Coefficients (β)	t-value	p-value	Remarks
(Constant)	121.578	6.666		18.238	0.000	
PIPE A	-10.387	4.817	-0.327	-2.157	0.033	Significant
MEEBES A	-5.980	3.167	-0.234	-1.888	0.061	Not Significant
MDSP A	-0.721	4.903	-0.022	-0.147	0.883	Not Significant

The model summary of the predictors in the board examination performance of Mechanical Engineering is displayed in Table 6. Having a p-value of 0.033, Power and Industrial Engineering (PIPE) can highly affect the result of the board examination for Mechanical Engineering. Mathematics, Engineering Economics, and Basic Engineering Sciences (MEEBES) cluster have a p-value of 0.061, hence, ranks second in predicting the outcome. Meanwhile, the Machine Design, and Shop Practice (MDSP) cluster can least predict the result since it has a high p-value which is 0.883. This means that the academic performance in Machine Design, Materials, and Shop Practice (MDSP) is almost the same as the performance in the board exam. However, in the study of Dotong (2019) only the Mathematics, Engineering Economics, and Basic Engineering Sciences cluster is a predictor of the board examination for the Mechanical Engineering program.

Also, a mathematical model that could predict the performance of the board exam was developed using the model summary of Table 5 through multiple linear regression to attain the fifth objective. The said linear regression equation is given by:

Board Examination Rating = 121.578 – (10.387*PIPEA) – (5.980*MEEBESA) – (0.721*MDSPA)

where:
PIPEA is the weighted average of academic performance in Power and Industrial Plant Engineering
MEEBESA is the weighted average of the academic performance in Mathematics, Engineering Economics, and Basic Engineering Sciences
MDSPA is the weighted average of academic performance in Machine Design and Shop Practice

An average percent error of 6.3257% was computed when the model was simulated to the graduates' academic performance. The percent error is simply the difference between the estimated and the actual value all over the actual value.

Employing logistic regression analysis to predict whether an examinee will pass or fail in the Mechanical Engineering Board Examination, a mathematical model was formulated as:

$$P = \frac{1}{1+ e^{-\{16.5924+[(-1.9921 MEEBES\ A)+(-5.60296\ PIPE\ A)+(-2.329647\ MDSP\ A)]\}}}$$

where:

P is the probability of 1 and e is the base of the natural logarithm. The logistic regression model classifies data based on the set cut-off of 0.70 or 70% or simply the passing grade. When data are simulated, and the result is greater than or equal to 0.70 or 70% the examinee is predicted to pass.

A classification table found in Table 7 shows the simulation of the Mechanical Engineering graduates' academic performance employing logistic regression analysis. The classification result showed that for the 111 successful predictions, 100 examinees were categorized successfully and 11 were failed observations.

Table 7. Classification table of the logistic regression analysis for Mechanical Engineering outcome

Prediction	Successful Observation	Failed Observation	Total
Successful	100	11	111
Failed	8	8	16
Total	108	19	27
Accuracy	0.925926	0.421053	0.8504
Cut - off	0.70 or 70%		

Of the 16 examinees who were categorized under failed, eight (8) were correctly categorized and eight (8) were incorrectly categorized. The successful observation has an accuracy of 92.59% and 42.11% for the failed observation. The developed mathematical model has a total accuracy of 85.04% at a cut-off of 70% as the passing grade. The successful observation is composed of data that is predicted to pass and successfully categorized as passed, or it could be data that is predicted to fail and is categorized as failed based on the simulation. Meanwhile, failed observations are the result of the simulation is different from the prediction. Using the Discriminant analysis with the general weighted average in Industrial and Power Plant Engineering; Mathematics, Engineering Economics, and Basic Engineering Sciences and Machine Design, Materials, and Shop Practice represented by PIPE A, MEEBES A, and MDSP A respectively as the predictors, the developed model is:

$$D = -11.573 + (5.823* PIPEA) + (0.931*MEEBESA) - (2.592*MDSPA)$$

The discriminate scores were classified based on the calculated group centroid of -0.148 for pass and 0.844 for fail.

Table 8. Classification result of the discriminant function for Mechanical Engineering outcome

		Classification Results		
	Rating	Predicted Group Membership		Total
		0.00	1.00	
Original	0.00	12	7	19
Count (%)	1.00	32	76	108
	0.00	63.2	36.8	100
	1.00	29.6	70.4	100

The classification results of the discriminate function for Mechanical Engineering as shown in Table 8 reveal that out of 127 examinees, 76 examinees were correctly classified as passed and 12 were correctly predicted as failed. However, 39 examinees were not correctly classified, as there were 32 examinees predicted to fail but were able to pass and seven (7) examinees were expected to pass but they obtained a non-passing mark during the board examinations. Moreover, the table revealed the accuracy of the discriminant function in classifying data with its sensitivity of 70.4% and specificity of 63.2%. A higher value of sensitivity means there are few false-negative results and a higher specificity means there are few false-positive results.

A developed path model of the Mechanical Engineering program illustrated in Figure 1 depicts possible paths of the exogenous variables and the endogenous variables were considered. The variables MEEBESA, PIPEA, and MDSPA were the exogenous variables, and those are the weighted average of the academic performance of the graduates per subject cluster. On the other hand, the variables MEEBESB, PIPEB, MDSPB, and RATING were the endogenous variables about the rating per subject cluster in the licensure examination. The variables e1, e2, and e3 were the disturbance on the endogenous variables and were not correlated with the exogenous variables. Double-head arrows were drawn to determine the covariances among the exogenous variables and single arrows were drawn to determine the effect of the exogenous variables on the endogenous variables. The term exogenous variables refers to the explanatory variables that are not correlated with the error term while endogenous variables are any variables correlated with the error term or carry the information about the error term (e). The hypothesized path model serves as the framework of the path analysis model. Some paths were deleted until the model was identified after multiple simulations of the path model.

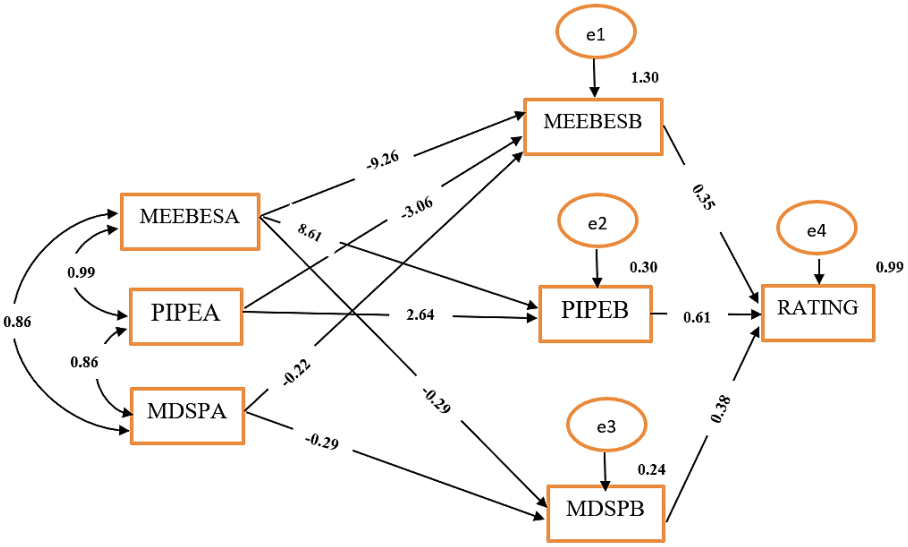

Figure 1. Developed path model for the Bachelor of Science in Mechanical Engineering Program

In this figure, MEEBESB, PIPEB, and MSDPB show a direct path toward the RATINGS as these were the components of the board ratings. MEEBESA, PIPEA, and MSDPA show a direct path to MEEBESB, with MEEBESA having the highest total effect of -9.26, followed by PIPEA with a total effect of 8.61 and MDSPA with the least total effect of 0.32. This implies that the academic performance of the graduates in Mathematics, Engineering Economics, and Basic Engineering Sciences and Power and Industrial Plant Engineering can affect the rating performance of the graduates in Mathematics, Engineering Economics, and Basic Engineering Sciences cluster.

Meanwhile, both MEEBESA and PIPEA have a direct effect on PIPEB with a total effect of 3.065 and 2.639, respectively. MEEBESA directly influenced MDSPB with a total effect of -0.22 and MDSPA with a total effect of -0.290. It can be seen from the path model that MDSPA has the least total effect on the endogenous variables. Thus, this supported the result of the multiple regression analysis that Power and Industrial Plant Engineering (PIPE) and Mathematics, Engineering Economics and Basic Engineering Sciences (MEEBES) are the predictors of the performance of the Mechanical Engineering board exam.

To answer the last objective, an unstructured interview with mechanical engineering students, alumni as well as faculty members of the College of Engineering, and accreditors to give their insights and feedback regarding the facilitating factors that compel to the success of the Mechanical Engineering board exam performance which is shown in Table 9.

Table 9. Facilitating factors affecting the success of the Mechanical Engineering board examination

Item No.	Determinants	Constructive Observations/Criticisms	Proposed Strategies
1	Mechanical Engineering Curriculum	The quality of the Mechanical Engineering curriculum here in the Philippines seems to be behind already compared to the curriculum in the universities abroad. Since the Mechanical Engineering program is one of the oldest engineering disciplines, it must conform to new trends. (i.e. integrating engineering simulations as elective, mechatronics, or intelligent systems and artificial intelligence). Reduce loadings and incorporate only Mechanical Engineering-related subjects. There is still a gap between the academe and industry and the course content must align with the real-world practice.	There must be an extensive curriculum review, consultations, benchmarking of best practices, alignment, and some academic reformation to cope with the curriculum and education system abroad. Development of departmental OBE framework. Strengthen academic-to-industry partnerships. Alignment of course content to the Table of Specifications (TOS) for the examination.
2	Laboratory facilities and classrooms	There are laboratory facilities that are already outdated. Inadequate financial allocation for the purchase of laboratory equipment or devices. Laboratory rooms and classrooms are not spacious for 50 and above class size. More hands-on laboratory output for appreciation, understanding, and validation of the theories behind the lecture.	Upgrade laboratory facilities that are already outdated. Aligning with the facilities found in the industry. Construction of spacious and conducive learning laboratory infrastructure Interactive smart classrooms.

3	The academic attitude of students	Most of the mindset of Mechanical Engineering students are already contented with obtaining a passing grade of 75 or 3.0. Lethargic behavior of some students towards academic studies. Habitual absenteeism among students.	Continuous student monitoring, and academic advisership especially for Mechanical Engineering students who have trouble with their grades. Implementation of a reward system for students who are excelling for upliftment. Conduct remedial class or learning recovery program by the Jr. PSME student organization. Strict observance of retention policy.
4	Academic STRAND	The freshmen students who want to take the Mechanical Engineering program are open also to non-STEM academic strands such as ABM, GAS, TECH-VOC, and HUMSS.	Conduct the so-called bridging program in basic mathematics and science for non-STEM academic strands. Engineering qualifying examination for non-STEM strand.
5	Health and environmental conditions	The effect of the COVID-19 pandemic has a significant consequence in the educational set-up. (i.e. transition from online to face-to-face class) Stress academic conditions that might affect their mental and physical health.	Semestral medical, neuropsychological examination program for students. Departmental outings for relaxation.

CONCLUSION AND RECOMMENDATION

In conclusion, the Mechanical Engineering graduates of 2011 - 2020 have an overall board passing rate of 85.039% and a mean rating of 75.7405, which is above the passing rate score of 70. Both Mathematics, Engineering Economics and Basic Engineering Sciences (MEEBES), and Machine Design, and Shop Practice (MDSP) have the same passing percentage of 99.213%, with a mean rating of 76.441 and 75.394 respectively. Meanwhile, Power and Industrial Plant Engineering (PIPE) has a passing rate is 94.488%, with a mean of 75.339. Moreover, the correlation coefficient result showed that there is a significant association between the academic performance and the licensure examination performance of the Mechanical Engineering graduates as indicated by the computed p-value of 0.000 which is less than 0.05.

Using the path analysis, MEEBESA, PIPEA, and MDSPA show a direct path to MEEBESB with MEEBESA having the highest total effect of -9.26, followed by PIPE A with a total effect of 8.61 and MDSPA having the least total effect of 0.32. It implies that the academic performance of the graduates in MEEBES and PIPE can affect the licensure performance of the graduates in MEEBES cluster. Both MEEBESA and PIPE A have a direct effect on PIPE B with a total effect of -3.06 and 2.64 respectively. MEEBESA directly influenced MDSP B with a total effect

of -0.22 and MDSPA with a total effect of -0.29. It can be seen from the path model that MDSPA has the least total effect on the endogenous variables or simply the dependent variables.

The inclusion of Course Audit subjects, also known as Review subjects as part of the outcomes-based education in the Mechanical Engineering Curriculum, must be sustained since these positively impact the result of the board examination. Moreover, it is advised that undergraduate students develop a study habit of understanding the concepts, principles, and manipulation of equations or formulas on how they are being applied rather than memorization. In this way, they will be able to grasp comprehension of whatever kind of problem-solving that can be encountered. Also, familiarization with the so-called "Rule of Thumb" in the standards of measurements and specifications and strengthening hands-on or actual laboratory set-ups that are being used in the industry would increase further understanding and visualization of the theories and concepts behind the lessons discussed.

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