British Journal of Education, Society & Behavioural Science
4(12): 1621-1629, 2014

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Predictors of Engineering Licensure Examination Using Logistic Regression

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Authors' contributions

This work was carried out in collaboration between authors AMT and RC. Author AMT designed the study, reviewed the literature, conducted the data analysis and wrote the paper. Author RC handled the application of findings in the general class of engineering students and made updates on the work. Both authors read and approved the final manuscript.

Original Research Article

Received 10th May 2014
Accepted 23rd June 2014
Published 27th July 2014

ABSTRACT

This study employed logistic and linear regression to determine strength of influence of grade point average (GPA), correlation course which is an intervention program offered in the University of Mindanao, Philippines, and the subject clusters of a board exam for admission to the profession of electronics and communication engineering.

The study covered periods from 2009 to 2011. Estimation revealed that the correlation course able to predict a board exam outcome than the GPA of the students. However, it was determined that safe GPA is 3.5; while 2.6 for the correlation course. This correlation course is a form of an intervention program that is added in the curriculum where students need to complete and pass.

The electronics and communication engineering program of the University of Midnanao, Philippines offer quality academic training in mathematics and electronics while finds difficulty on applied electronics and electronics science and technology.

A simulation revealed the safe scores for a 100-item board exam subjects: mathematics (65); electronics (65); general electronics and applied science (75); and electronics

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technology and science (75).
The board performance of the program seemed to show a rather erratic movement which indicates loose foothold toward the exam.

Keywords: Licensure; intervention; logistic regression.

1. INTRODUCTION

The assurance of preparedness of engineering professionals for the industry remained to be a continuous system in many countries through the process of accreditation [1]. The accreditation served as a sketch pad for collaboration of the industry, the engineering educators and the educational researchers [2]. The collaboration allowed for developing assessment techniques to improve classroom management, courses and curricula [3]. It is imperative for the industry and the educational institution to work together because of the need to produce graduates that meet the global standards of hard engineering skills and the requirements of the six professional skills set by ABET such as communication, teamwork, self-assessment, lifelong learning, change management and problem-solving skills [4]; Woods, Felder, [5]. However, Mills & Treagust [6] even earlier found that engineering graduates are bereft of the said skills.

Although there already are sets of skills that must be learned, graduates finished the degree without completing them. This instead placed graduates' competencies disproportionate with the industry's requirement. The situation leads to a paradigm shift in the accreditation of the profession by looking at the outcomes competencies of the graduates [6,7,5] from ordinary skills set. The aim of the change is still much the same; engineering professional must be able to work across cultural, geographical and disciplinal borders [8].

Meantime, the need for engineering education reforms is felt far and wide [9-12]. Jianzhong revealed the discordance between China's engineering education with the market which Galloway sternly proposed educational reforms to ride with the changing trend of a globalized society. While Sjöholm blamed the educational system for the low outputs in production industries like electronics to which Wulf echoed the urgency of reforms. Resnick & Resnick suggested that educational reforms must be coupled with testing reforms to address, at the instance of occurrence, the assessment quality in the engineering education.

In addition, higher learning institutions instructional strategies must be able to prepare students achieve outcomes expected of a graduate [7]. These strategies include computer-based simulations and clinical skills assessments [13], use of academic aptitude and self-image to predict performance in the licensure exam [14], offering of an intervention course to ready students for the licensure examination [15-18], model building of subjects clusters [19], enhancement of the curriculum [20,21], profiling of successful takers [22], and career programming [23]. Crow et al., [24] studied program requirements and educational interventions to predict passing the nursing licensure exam, to which Sifford and McDaniel [25] empirically determined an intervention program as having significant effect to students.

This study was conducted to determine predictors of the University of Mindanao electronics and communication graduates' ability to pass the licensure examination. In addition, this paper will serve as an impact assessment of the intervention program referred in this study as correlation course towards passing the State-sponsored licensure exam.

2. METHODS

The study employed a causal design for research [26]; O'Connell & Gray [27,28]. This type of quantitative research aims to determine the influence of sets of variables on a particular variable of interest, in this study, the predictors of passing the licensure exam.

The method of maximum likelihood estimation was used to obtain the maximum parameter estimates in the nonlinear model used in this paper [29]. The maximum likelihood choose the maximum $Ln(p)$ as such

$$\ln(Ln(p) = \left(\sum_{i=1}^{n} Y_j\right)\ln(p) + \left(n - \sum_{j=1}^{n} Y_j\right)\ln(1-p)$$
$$= n\left(\bar{Y}\ln(p) + (1-\bar{Y}\right)\ln(1-p)$$

[eq.1]

Where $\bar{Y} = \frac{1}{n}\sum_{j=1}^{n} Y_j$ is the sample mean.

The logistic regression which is widely used tool in medical science [30] and other sciences [31] was used in this paper.

The general logit model takes the form:

$$\Pr\left[Y_j = 1 \mid X_{ij},..., X_{kj}\right] = \frac{1}{1+\exp(-\beta_1^0 X_{ij} - ... - \beta_k^0 X_{kj}}$$
$$= \frac{1}{1+\exp(-\sum_{i=1}^{k}\beta_i^0 X_{ij}}$$

[eq.2]

Where one of the X_{ij} equals 1 for the constant term, say $X_{kj=1}$, and the β_i^0 are true parameter values which can be estimated in the maximum likelihood manner. The log-likelihood function is

$$\ln(Ln(\beta_1,...,\beta_k)) = -\sum_{j=1}^{n}(1-Y_j)\sum_{i=1}^{k}\beta_i X_{ij} - \sum_{j=1}^{n}\ln(1+\exp(-\sum_{i=1}^{k}\beta_1 X_{ij}))$$

[eq. 3]

and the maximum likelihood estimators $\hat{\beta}_1,...,\hat{\beta}_k$ are obtained by maximizing $\ln(Ln(\beta_1,...,\beta_k))$

$$\ln(Ln(\hat{\beta}_1,...,\hat{\beta}_k)) = \max_{\beta_1,...\beta_k} \ln(Ln(\beta_1,...,\beta_k))$$

[eq.4]

If sample (n) is large, then $i = 1,...,k$,

$$\sqrt{n}(\hat{\beta}_i - \beta_i^0) \sim N[0, \sigma_1^2]$$

The estimators $\hat{\sigma}_i^2$ of the variances σ_i^2 takes

$$\frac{\sqrt{n}\left(\hat{\beta}_i - \beta_i^0\right)}{\hat{\sigma}_i} \sim N[0,1] \text{ for } i = 1,...,k.$$

[eq.5]

3. FINDINGS AND ANALYSIS

Table 1 shows the academic performance of the electronics and engineering students from 2009 to 2011 represented by the GPA (grade point average) and the grade in the correlation which is an intervention course. The GPA, the representation of the academic ability of the students, showed a maximum grade of 1.9 (representing a grade of 91), lowest of 3.5 (which is a grade of 75)[1] and with average of 2.87 (82) with a standard deviation of 0.39.

The correlation, a University instituted enhancement embedded in the curriculum indicated a maximum grade of 2.8 (82), 3.5 (75) as the lowest and an average of 3.37 (77) with a standard deviation of 0.18. The discreet gap between the GPA and the correlation grades seemed to be very evident. The academic performance, on the whole, was displaying a rather convenient threshold compared to the correlation as a review course.

Table 1. Descriptive statistics of the GPA and correlation

Academic performance	Max	Min	Average	St dev
GPA	1.9	3.5	2.87	0.39
Correlation	2.8	3.5	3.37	0.18

A trend evaluation would point out that the year-end examinations experienced a downturn, while the midyear performance displayed an erratically vacillating performance.

Table 2 presents the number of passers and flunkers of the board exam from period 2009 to 2011. In principle, an erratic board performance indicates a more serious concern because of a loose foothold on the qualifying exam for practice of profession. This merits a narrowed and directional investigation on the strength of the program relative to the board.

[1] In the University of Mindanao, the perfect score is 1.0 and the score reduces as it increases by decimal value . For example, a grade of 1.1 is actually a grade of 99, a grade of 1.2 is 98 and so on until it reaches the minimum acceptable score of 75. A score of 75 which is actually equal to 3.5

Table 2. Passers, flunkers per exam, 2009-2011

Date of exams	Passers	Flunkers	%of passing
Mar-09	6	11	35.29
Oct-09	5	17	22.73
Apr-10	3	6	33.33
Nov-10	1	14	6.67
Apr-11	2	10	16.67
Oct-11	5	6	45.45

The Philippine law on electronics and communication engineering, RA 9292, required that all applicants to be registered and licensed for the practice of the profession shall undergo examinations[2] which subjects were clustered as Mathematics (here in the study was interchanged at some instance with subj1), Electronics (subj2), General electronics and applied science (subj3) and electronics science and technology (subj4). The professional board examination is given twice a year by the government; the month is also determined by the government of the Philippines.

Table 3 presents the number of passers, flunkers and percentage of passing per subject cluster for period 2009 to 2011. It was observed that students were standing on a loose ground for general electronics and applied science and in electronics science and technology subject, while the strength is observed on mathematics and electronics subject clusters.

This suggests that the program holds a strong background on basic electronics and in engineering mathematics, but was finding some difficulty in general practice and application on science and technology. This is a concern of professional exposure, linkages and industry feedback.

Table 3. Passers, flunkers per subject cluster, 2009-2011

Subject cluster	Passers	Flunkers	% of passing
Subj1	43	43	50.00
Subj2	37	49	43.02
Subj3	24	62	27.91
Subj4	25	61	29.07

Table 4 presents the minimum, maximum and average scores of the students in the board exam from 2009 to 2011. This is in pursuit of identifying the strengths and weaknesses of the program relative to the licensure examination. The results were consistent. The highest average grades were observed for subject clusters mathematics and electronics while a relatively lower scores were observed among the general electronics and applied science and in science and technology.

An empirical test was employed to determine the strength of influence of the GPA and the correlation grade into the probability of passing the licensure examination. The test revealed that both the GPA and the intervention determined the probability of passing. Table 5

[2] *RA 9292, Article 3 section 13 defines the licensure examination requirement that includes among others as required by the Board the mathematics, applied sciences, engineering economics, laws and ethics, electronics, communications, computers and information and communication technology*

presents the probability estimation in simulating the GPA and the grade in the correlation course which is the intervention program.

Table 4. Minimum, maximum and average scores per cluster, 2009-2011

	Minimum	Maximum	Mean	Std. deviation
Subj1	31	89	66.31	14.67
Subj2	43	92	66.87	12.14
Subj3	29	89	57.28	15.22
Subj4	32	90	58.57	14.60

Further note that the intervention bears a stronger influence on the licensure exam than the GPA which is driving a good point. There might be a float up in the student's grade which did not necessarily lead to an enhanced skills and theories in readily stocking for practice of profession. Their academic performance was bridled for theoretical agglomeration bland of practice which is so far unique compared to other engineering courses[3]. More so, the threshold grade for GPA and correlation course are 3.5 (75) and 2.6 (84) respectively to obtain a successful board outcome.

Table 5. Simulation of probability to pass with predicted grade

Simulation	GPA -2.30*	Correlation -4.68*	Probability estimate	Predicted Grade
GPA=1.9; Corr=2.8	0.19	0.03	0.00	85.89
GPA=3.5;Corr=3.5	0.35	0.04	0.00	51.81
GPA=2.87;Corr=3.37	0.29	0.03	0.00	62.11
GPA=3.5; Corr=2.6	0.35	0.03	0.00	70.60

Table 6 shows an empirical test to determine strength of relationship of the subject clusters towards passing the board exam.

An investigation on the strength of influence of the subject clusters: subj2 had the strongest influence, followed by subj3, then by subj4 and subj1 with the relatively lowest influence though not dispensable. It was found that a 1 unit increase in subj1, there is a 18 percent increase chance that the student will pass the board exam, while a 1 unit increase for subj2, subj3 and subj4 increases the chance of passing the board exam by 30 percent, 28 percent and 24 percent respectively.

A simulation was conducted to determine the threshold score for each subject cluster. Table 7 shows the predicted score from the simulated scores in the subject cluster of the board exam. The simulation of the ratings took cognizance of the ECE law, RA 9292, which requires a rating no lower than 60 percent for each subject and overall rating of 70 percent. The simulation score column would be indicative of the target score in the board and the predicted score column would represent the overall rating.

[3] Correlation for mechanical engineering and civil engineering were not significantly simulating the board exam; while the pre-review for accounting education (the equivalent of correlation) was significantly forecasting a board outcome

Table 6. Regression results to determine significant influence

Predictor	Beta coefficients	Std. Error	T	p-value
Constant	0.36	0.91	0.4	0.69
Subj1	0.18	0.01	12.52	0
Subj2	0.3	0.02	15.82	0
Subj3	0.28	0.02	15.02	0
Subj4	0.24	0.02	13.07	0
R-squared=89.20				
Adjusted R-squared=88.7				

Table 7. predicted score by simulated cluster score

Score simulation	Predicted score
Subj1=66.31;subj2=66.87;subj3=57.28;subj4=58.57	62.21
Subj1=89;subj2=92;subj3=89;subj4=90	90.18
Subj1=63;subj2=65;subj3=75;subj4=75	70.00
Subj1=65;subj2=65;subj3=75;subj4=75	70.35

In order to pass the board exam and be admitted to the registry of the electronics and communications engineering professionals, the applicant must aim to obtain a rating of 63 or better for mathematics (subj1); a rating of 65 or better in electronics; 75 or better in general electronics and applied science (subj3) and 75 or better in electronics science and technology.

4. CONCLUSION

The readiness of the engineering graduates to take the licensure examination is largely influenced by the learning institution. The study found that the institution should not only teach the students of the subjects; the institution must teach the students to learn. An intervention program that simulates the examination in the board exam for electronics and communication engineering graduates is seen as a good formula to improve the chances of passing. Also, a continuous review and assessment of the curriculum and courses will aid in strengthening the program and thereby making students ready for board examination, and when they graduate, being ready for assimilation in the industry.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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