JOURNAL OF COMPUTATIONAL INNOVATION AND ANALYTICS
https://e-journal.uum.edu.my/index.php/jcia

How to cite this article:
Patungan, A., De Jesus, V. P., Fajardo, R. Z., & Valondo, M. A. (2025). A computational analysis of engineering licensure outcomes under curricular change using propensity score matching. *Journal of Computational Innovation and Analytics*, *4*(2), 70-79. https://doi.org/10.32890/jcia2025.4.2.5

A COMPUTATIONAL ANALYSIS OF ENGINEERING LICENSURE OUTCOMES UNDER CURRICULAR CHANGE USING PROPENSITY SCORE MATCHING

[1]Arturo J. Patungan Jr, [2]Vitus Paul L. De Jesus, [3]Regina Zyra F. Fajardo, & [4]Micaela Allena T. Valondo
[1,2,3,4]Mathematics and Physics Department,
University of Santo Tomas, Philippines

[1]Corresponding author: ajpatungan@ust.edu.ph

Received: 13/05/2025 Revised: 04/07/2025 Accepted: 30/07/2025 Published: 31/07/2025

ABSTRACT

The Philippine higher education sector underwent a significant curriculum transition with the implementation of the K–12 program, which reduced the engineering curriculum from five to four years. This study examines the impact of this change on the licensure examination performance of engineering graduates. A causal-comparative design was used, with propensity score matching (PSM) applied to control for confounding variables such as age, sex, academic performance, exam timing, and degree program. Both nearest-neighbor and full matching methods were tested, with full matching selected for its superior covariate balance and sample retention. Using the matched dataset, logistic regression modeling revealed that graduates under the new 4-year curriculum had significantly lower odds (OR = 0.94) of passing the board exam than those under the 5-year track. The marginal mean comparison showed a 6.06 percentage point decrease in passing probability for the new curriculum group ($p < .001$), with a Cohen's d of –0.53, indicating a moderate negative effect. These findings suggest that transitioning to the restructured 4-year engineering curriculum has not yet translated into improved licensure performance. A closer review of curriculum content, implementation fidelity, and academic support programs is needed to address this gap and strengthen outcomes under the reformed education system.

Keywords: curriculum evaluation, engineering licensure, licensure examination, propensity score matching, Philippines

INTRODUCTION

The engineering education landscape in the Philippines has been substantially affected by the national K to 12 educational reform. Prior to this change, engineering programs typically spanned five years. Beginning the academic year 2018–2019, however, the curriculum was streamlined to four years after several foundational college-level subjects were moved to senior high school (Cabaces, 2018). This shift followed the Enhanced Basic Education Act of 2013 (Republic Act No. 10533), which envisioned the additional two years of senior high school adequately preparing graduates for employment or entrepreneurship without requiring a college degree (Official Gazette, n.d.). Nearly a decade later, this promise remains contested. Many graduates continue to face challenges in employability (Navarro, 2022; Orbeta & Potestad, 2020).

This higher education curricular adjustment has raised questions about its impact on students' academic and professional outcomes, particularly licensure performance. While several studies have explored predictors of engineering licensure exam results (Mallari & Bueno, 2018; Rivera, 2021), limited evidence directly compares licensure outcomes between students from the old five-year curriculum and those from the new four-year program.

To address this gap, the present study evaluates whether the shift in the college engineering curriculum has a measurable effect on licensure examination outcomes. Given the observational nature of the data and the non-random assignment of students to curriculum types, Propensity Score Matching (PSM) was used to create a more balanced comparison between the two groups. By matching students based on observed characteristics such as sex, academic performance, and student classification (regular or irregular), the analysis aims to isolate the effect of curriculum type on licensure results more credibly.

The use of PSM in this study is grounded in its demonstrated advantage for handling observational data, particularly where binary treatments are involved. Compared to regression-based methods, PSM is often preferred for several reasons. First, it allows a more straightforward interpretation of the relationship between treatment and outcome. Second, it helps eliminate residual imbalance in covariates. Third, it offers more flexibility when rare outcomes and treatment assignments are common (Braitman & Rosenbaum, 2002). Lastly, PSM enables explicit comparison between treatment groups with overlapping distributions of observed covariates, which is often more difficult to ensure in regression-based approaches (Austin, 2011; Imbens, 2004).

Previous applications of PSM in various disciplines underscore its versatility and rigor. For instance, Drichoutis et al. (2009) assessed the impact of nutritional label use on BMI using PSM, while studies by Imbens (2000), Joffe and Rosenbaum (1999), and Hirano and Imbens (2004) have extended the method to accommodate multiple and continuous treatments. In these works, matching estimators performed well in constructing artificial comparison groups and minimizing confounding.

In this study, PSM allowed the construction of a quasi-experimental setting that supports more valid causal interpretations. Logistic regression was subsequently applied to the matched sample to quantify the treatment effect of the curricular change. This sequence of methods strengthens the robustness of the findings.

This study aims to evaluate the impact of the revised engineering curriculum on licensure examination performance in the Philippines. Specifically, it seeks to:

1. Assess the baseline differences in observed characteristics between the two groups to establish a covariate balance for propensity score matching. These characteristics include:
    a. Sex
    b. Age at graduation
    c. Degree program
    d. General Weighted Average (GWA)
    e. Student status (regular or irregular)
    f. Board examination date
2. Compare the passing rates of the licensure examination between graduates of the old five-year and the new four-year curriculum using matched samples.

METHODOLOGY

Research Design

This study employed a quantitative causal-comparative research design to investigate the effect of the college curriculum on licensure examination outcomes. The independent variable was the curriculum type (old five-year curriculum vs. new four-year curriculum), and the dependent variable was the licensure examination result (pass or fail). Several covariates were considered to control for potential confounding factors, including sex, age at graduation, degree program, general weighted average (GWA), total years in the program, and timing of taking the board exam. This design allowed for comparing two naturally occurring groups of graduates (those from the old and new curricula) to discern any significant differences in their licensure performance.

Data Collection

The data for this study were obtained from a private engineering higher education institution in the Philippines. Graduates from two cohorts were included: those who completed the engineering program in 2018–2019 under the old curriculum (curriculum =0) and those who graduated in the academic year 2022–2023 under the new curriculum (curriculum =1). Records for these graduates were collected from the university's database, including each graduate's sex, date of birth, engineering degree program (Chemical, Civil, Electrical, Electronics, or Mechanical Engineering), GWA, student status (regular =1, irregular =0), graduation date, and whether the graduate took the first available licensure examination after graduation (exam timing = 1).

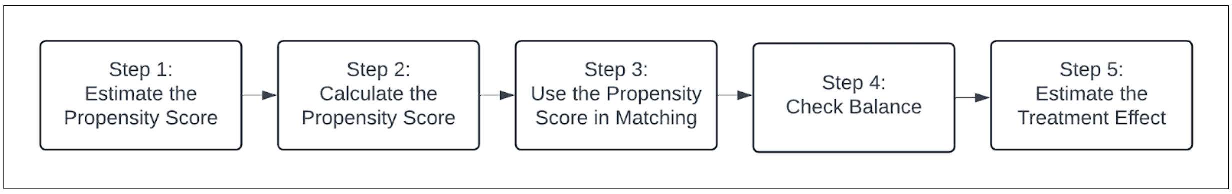
Licensure examination outcomes were determined by cross-referencing graduate names with the Professional Regulation Commission's list of engineering board passers from 2018 to 2023. Graduates were classified as passers if their names appeared in the database within this period. The initial data collection yielded 2,803 graduate records. After removing incomplete and duplicate entries, 2,780 graduates remained: 1,383 from the old curriculum and 1,397 from the new curriculum.

Statistical Treatment

To reduce selection bias and ensure comparability between the two groups, Propensity Score Matching (PSM) was used as the primary statistical technique (Austin, 2011) as illustrated in Figure 1. The propensity scores were estimated by building the propensity model.

Figure 1

Propensity Score Matching Flowchart



A logistic regression model was constructed to estimate the propensity score for each graduate, representing the conditional probability of being part of the new curriculum group given a set of covariates. These covariates included sex, age at graduation, degree program, GWA, student classification (regular or irregular), and first exam taker status.

The estimated model was of the form:

$$\log(odds\ T = 1) = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n$$

where:

$odds\ T = 1$ is the probability of the graduates being from the new curriculum
β_0 is the intercept
β_1 to β_n are the coefficients of the predictor variables
X_1 to X_n are the predictor variables

Initially, a 1:1 nearest-neighbor matching without replacement was applied using a caliper of 0.2 standard deviations of the logit of the propensity score. This reduced the risk of poor matches but resulted in 14 unmatched treatment units and residual imbalance in covariates such as GWA, student status, age, and first-time taker status.

The study adopted Full Matching to improve balance, where each treatment unit is matched to one or more control units and vice versa. This method retained all sample units and minimized global imbalance. Post-matching diagnostics showed reduced standardized mean differences (SMDs) and empirical cumulative distribution function (eCDF) statistics. The eCDF mean and maximum values reflect the average and maximum distance between cumulative distributions of covariates across groups, with lower values indicating better covariate overlap. Balance summary tables and matching statistics were reported in the results section.

Following matching, a logistic regression analysis was conducted on the matched sample to estimate the effect of curriculum type on the probability of passing the licensure examination. In this post-matching model, licensure exam results (pass or fail) served as the dependent variable, and curriculum type was the primary predictor. Statistical significance was assessed using Wald tests, with p-values less than 0.05 considered indicative of meaningful differences.

All analyses were conducted using R statistical software, the MatchIt package for matching, and base R functions for regression analysis. While PSM accounts for observed covariates, the possibility of unobserved factors, such as implementation fidelity or curriculum delivery differences, remains and is acknowledged as a study limitation.

ANALYSIS AND RESULT

Covariate Balance Before and After Matching

Before matching, notable differences were observed between graduates of the old and new curricula as shown in Table 1. Graduates from the new curriculum were slightly older at graduation (22.6 years vs. 21.9 years), more likely to graduate on time, and less likely to take the licensure examination at the first available schedule. They also had slightly better average general weighted averages (GWA), although variation in academic performance was wider. These imbalances are reflected in Table 1, which includes both standardized mean differences (SMD) and empirical cumulative distribution function (eCDF) statistics. The eCDF mean and maximum values represent the average and maximum differences in the cumulative distributions of covariates across the two groups, with lower values indicating better balance.

Table 1

Summary of Balance for All Data Before Matching

Variable	Means Treated	Means Control	SMD	eCDF Mean	eCDF Max
distance	0.813	0.189	2.8	0.441	0.756
chemical	0.137	0.143	-0.017	0.006	0.006
civil	0.357	0.307	0.106	0.051	0.05
electrical	0.114	0.15	-0.113	0.036	0.036
electronics	0.172	0.207	-0.093	0.035	0.035
mechanical	0.22	0.194	0.063	0.026	0.026
sex	0.297	0.278	0.041	0.019	0.019
age	22.579	21.948	0.97	0.065	0.37
Student status	0.947	0.793	0.687	0.154	0.154
GWA	1.895	2.322	-1.487	0.28	0.495
exam timing	0.464	0.743	-0.559	0.279	0.279

Two matching methods were tested to reduce selection bias and improve comparability: nearest-neighbor (NN) matching and full matching (Full). While nearest-neighbor matching (1:1, without replacement) was initially tested, it left several treatment units unmatched and retained residual imbalance in covariates like GWA, age, and student status, resulting in 14 unmatched treatment units. Full matching, in contrast, successfully retained the full sample and produced better overall balance across key variables. Both methods are compared as shown in Table 2.

Table 2

Summary of Balance for All Data for Nearest Neighborhood and Full Method

Variable	SMD (NN)	eCDF Mean (NN)	eCDF Max (NN)	SMD (Full)	eCDF Mean (Full)	eCDF Max (Full)
distance	2.834	0.446	0.765	0.000	0.003	0.036
chemical	-0.015	0.005	0.005	0.062	0.021	0.021
civil	0.106	0.050	0.051	-0.231	0.111	0.111
electrical	-0.118	0.038	0.038	-0.060	0.019	0.019
electronics	-0.094	0.035	0.035	-0.063	0.024	0.024
mechanical	0.066	0.028	0.028	0.319	0.132	0.132
sex	0.041	0.019	0.019	-0.163	0.074	0.074
age	0.980	0.066	0.374	-0.404	0.068	0.220
student_status	0.704	0.158	0.158	0.632	0.142	0.142
gwa	-1.502	0.283	0.502	-0.248	0.055	0.128
exam timing	-0.566	0.282	0.282	0.160	0.080	0.080

The full matching method was ultimately adopted for its ability to retain all cases while substantially reducing imbalance across covariates. This ensures that the comparison of licensure performance outcomes is based on groups that are statistically equivalent in background characteristics.

Licensure Examination Outcomes

Using the full-matched dataset, a logistic regression model was employed to estimate the probability of passing the licensure exam based on curriculum type and covariates, including degree program, sex, age, student status, GWA, and exam timing. Results are shown in Table 3.

Table 3

Logistics Regression Model

Predictors	Estimate	Std. Error	p-value	Odds Ratio	VIF
Intercept	0.446	0.183	0.015	1.562	
Curriculum	-0.061	0.016	<0.001	0.941	2.219
Chemical	0.030	0.020	0.138	1.03	1.577
Civil	0.020	0.016	0.212	1.02	1.879
electrical	0.074	0.020	<0.001	1.077	1.528
electronics	-0.047	0.018	0.008	0.954	1.59
sex	-0.015	0.013	0.249	0.985	1.123
age	-0.003	0.008	0.724	0.997	1.706
Student status	0.034	0.022	0.126	1.035	1.866
GWA	-0.026	0.020	0.209	0.975	2.094
exam timing	0.647	0.013	<0.001	1.909	1.353

The logistic regression model can be written as:

$$\log(p(1-p)) = 0.446 - 0.061(\text{Curriculum}) + 0.030(\text{Chemical}) + 0.020(\text{Civil}) + 0.074(\text{Electrical}) - 0.047(\text{Electronics}) - 0.015(\text{Sex}) - 0.003(\text{Age}) + 0.034(\text{Student Status}) - 0.026(\text{GWA}) + 0.647(\text{exam timing})$$

where:

- p is the predicted probability of passing the exam.
- Curriculum = 1 if new curriculum, 0 if old
- Degree programs are dummy coded relative to Mechanical Engineering (reference category)
- sex = 1 for male, 0 for female (or vice versa, based on coding)
- exam timing = 1 if taken immediately after graduation, 0 otherwise

This model shows that even after adjusting for confounding factors, students from the new curriculum have significantly lower odds of passing the exam ($p < 0.001$). In practical terms, this equates to an estimated 6% reduction in passing odds for new curriculum graduates, even after adjusting for background factors.

Marginal Means and Average Comparison

To enhance interpretability, the model was extended to estimate marginal means and group contrasts (see Table 4). The average predicted probability of passing was significantly lower for the new curriculum group. The contrast between the two groups' marginal means was –0.0606 (SE = 0.0174, z = –3.48, $p < 0.001$), with a 95% confidence interval of –0.0947 to –0.0264.

This corresponds to a Cohen's d of –0.53, indicating a moderate negative impact of the new curriculum on licensure exam performance.

Table 4

Marginal Means/Average Comparison Table

Term	Contrast	Estimate	Std. Error	z	Pr(>|z|)	2.5%	97.5%	Cohen's d
curriculum	1 - 0	-0.061	0.017	-3.48	<0.001	-0.095	-0.026	-0.527

Discussion and Interpretation

Several factors might explain the lower success rate of the new curriculum graduates. The reduction of one academic year could mean less time for in-depth coverage of certain technical subjects, potentially affecting graduates' readiness for the comprehensive licensure exams. Moreover, the first batch of new curriculum graduates (Class of 2022) experienced a portion of their college education during the COVID-19 pandemic, which likely disrupted learning experiences. It is also possible that both students and faculty were adjusting to the new curriculum, and some initial implementation challenges may have impacted student preparation. These considerations suggest that the new curriculum's debut coincided with circumstances that were not optimal for licensure exam performance.

Importantly, the findings of this study indicate that the intended benefits of the K–12 reform in higher education have not yet been fully realized in terms of licensure outcomes. In fact, the results echo broader concerns about the efficacy of educational reforms when not accompanied by sufficient support (Durban & Catalan, 2012; Reyes, 2000). For educators and policymakers, this highlights the need to monitor and enhance the new curriculum's implementation closely. Interventions such as curriculum refinements, improved instructional resources, and supplemental review programs for new curriculum students might be necessary to bridge the performance gap observed in the licensure examinations.

CONCLUSION AND RECOMMENDATIONS

In summary, the shift from a five-year to a four-year engineering curriculum under the K–12 educational reform appears to have had an adverse impact on licensure examination performance. Using propensity score matched comparisons, this study found that graduates of the new curriculum had significantly lower chances of passing their engineering board exams than graduates of the previous curriculum. This may suggest that the additional preparation provided at the senior high school level did not fully offset the reduction of one year in college for engineering students, at least in terms of readiness for professional licensure.

The findings highlight the need for stakeholders in engineering education to take proactive steps in response. Curriculum developers and educators should re-evaluate the content and pacing of the new four-year programs to ensure essential competencies are thoroughly covered. Additional support mechanisms—such as enhanced review courses, mentoring, or bridging modules—could be implemented to help students better prepare for the licensure exams. Further research is also recommended, extending the analysis to other institutions and subsequent graduate batches to determine if the observed trend persists. Future studies might incorporate additional factors such as the number of licensure exam attempts, graduates' study habits and review strategies, and student aptitude measures to understand better how the curricular change influences licensure performance over the long term.

ACKNOWLEDGEMENT

The authors would like to thank the University of Santo Tomas, College of Science, Mathematics and Physics Department for their invaluable support in this project and the reviewers and editors for their valuable contributions to improving the manuscript. This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Austin, P. (2011). An introduction to propensity score methods for reducing confounding effects in observational studies. *National Center for Biotechnology Information.* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3144483/

Cabaces, D. (2018). Engineering education in the Philippines. *International Journal of Advanced Research and Publications, 2*(12), 27–31.

Camello, N. C., Castro, E. L., Chavez, N. H., Dotong, C. I., Laguador, J. M., & Prenda, M. B. (2016). Tracer study of engineering graduates of one higher education institution in the Philippines for the academic year 2009–2012. *European Journal of Engineering and Technology, 4*(4), 37.

Durban, J. M., & Catalan, R. D. (2012). Issues and concerns of Philippine education through the years. *Asian Journal of Social Sciences and Humanities, 1*, 61–69.

Frost, J. (2022). Content validity: Definition, examples & measuring. *Statistics By Jim.* https://statisticsbyjim.com/basics/content-validity/

Griffen, A. S., & Todd, P. E. (2017). Assessing the performance of nonexperimental estimators for evaluating Head Start. *Journal of Labor Economics, 35*(S1), S56–S97.

Inquirer. (2018). What went before: The K-12 program. *Inquirer.net.* https://newsinfo.inquirer.net/980733/what-went-before-the-k-12-program

Joint Foreign Chambers. (2010). *Arangkada Philippines 2010: A business perspective.* https://www.investphilippines.info/arangkada/wp-content/uploads/2011/06/30.-Part-4-General-Business-Environment-Social-Services-Education.pdf

Luvsandorj, Z. (2023). A beginner's guide to propensity score matching. *Built In.* https://builtin.com/data-science/propensity-score-matching

Maaliw, R. R. (2021). Early prediction of electronics engineering licensure examination performance using random forest. In *2021 IEEE World AI IoT Congress (AIIoT)* (pp. 41–47). IEEE.

Maheshwari, V. K. (2018). Causal-comparative research. http://www.vkmaheshwari.com/WP/?p=2491

Mallari, G. C., & Bueno, D. C. (2018). Factors affecting the Civil Engineering Licensure Examination performance: A theoretical perspective. *Institutional Multidisciplinary Research and Development Journal, 1*, 1–10.

McCombes, S. (2021). What is a research design? *Scribbr.* https://www.scribbr.com/methodology/research-design/

Nathan, S.K., & Rajamanoharane, S.W. (2016). Enhancement of skills through e-learning: Prospects and problems. *The Online Journal of Distance Education and e-Learning, 4*(3), 10–20.

Navarro, D. (2022). 'Experimental' K-12 grads prove worth. *Daily Tribune.* https://tribune.net.ph/2022/10/23/experimental-k-12-grads-prove-worth/

Official Gazette. (n.d.). The K to 12 basic education program. *Official Gazette of the Republic of the Philippines.* https://www.officialgazette.gov.ph/k-12/

Orbeta, A., & Potestad, M. (2020). On the employability of the senior high school graduates: Evidence from the Labor Force Survey (Discussion Paper No. 2020-40). *Philippine Institute for Development Studies.*

Parrocha, A. (2023). DepEd to give updates on K-12 curriculum on Jan. 30. *Philippine News Agency.* https://www.pna.gov.ph/articles/1192378

Permatasari, D. A., & Mardapi, D. (2019). Competency profile of electrical engineering graduates relevant to the industry. In *Proceedings of the 2019 International Conference of Science and Technology for the Internet of Things.*

Private Education Assistance Committee. (n.d.). *RA 10533. Official text of Republic Act 10533.* https://ovap.peac.org.ph/about/ra10533

Professional Regulation Commission. (2022). *History.* Professional Regulation Commission (PRC). https://www.prc.gov.ph/history

Professional Regulation Commission. (2024). *Republic of the Philippines Professional Regulation Commission.* https://www.prc.gov.ph/

Qadir, J., Kok-Lim, A. Y., Imran, M. A., & Al-Fuqaha, A. (2020). Engineering education, moving into 2020s: Essential competencies for effective 21st century electrical & computer engineers. In *2020 IEEE Frontiers in Education Conference (FIE).* IEEE.

Reyes, F. C. (2000). *Engineering the curriculum: A guidebook for educators and school managers.* Manila, Philippines: De La Salle University Press.

Rivera, E. R. (2021). Exploratory data analysis (EDA) of the performance of Philippine higher education institutions in the Electronics Engineering Licensure Examinations. *IECEP Journal, 4*(1), 1–8.

Setiawan, H., & Raharjo, F. (2019). Knowledge, skills and attitudes of civil engineers in Indonesia. *IOP Conference Series: Materials Science and Engineering, 615*(1), 012030.

Southeast Asian Ministers of Education Organization, Regional Center for Educational Innovation and Technology (SEAMEO INNOTECH). (2012). *K to 12 toolkit: Resource guide for teacher educators, school administrators and teachers.* https://www.seameo-innotech.org/wp-content/uploads/2020/05/k-12-toolkit.pdf

Sundjaja, J. H., Shrestha, R., & Krishan, K. (2022). McNemar and Mann-Whitney U tests. *National Center for Biotechnology Information.* https://www.ncbi.nlm.nih.gov/books/NBK560699/

Terano, H. J. R. (2018). Regression model of the licensure examination performance of electronics engineering graduates in a state college in the Philippines. *Advances and Applications in Mathematical Sciences, 18*(2), 197–204.

World Economic Forum. (2011). *The Global Competitiveness Report 2011–2012: Digital TV – Higher Education and Training.* https://www3.weforum.org/docs/GCR2011-12/17.GCR2011-2012DTVHigherEducationandTraining.pdf

Wulandari, M., Nusantara, D. A. D., Rahmadyanti, E., & Mulyono, W. D. (2022). Tracer study of alumni competencies in Civil Engineering Department Universitas Negeri Surabaya. In *Proceedings of the International Joint Conference on Science and Engineering 2022*