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Input Process Output (IPO) Framework for Engineering Higher Education Accreditation in Indonesia*

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While higher education accreditation is widely acknowledged for its benefits, it remains subject to criticism. Critics have expressed certain concerns, including the observation that accrediting bodies often exhibit a preference for an input-centric approach despite the recent trend towards emphasizing outcomes. However, establishing predetermined accreditation criteria for evaluating the performance of educational institutions is a complex and formidable undertaking. LAM Teknik, an Independent Engineering Accreditation Agency in Indonesia, is relatively new. Nevertheless, it has developed accreditation assessment criteria based on the Input-Process-Output (IPO) framework, which has been put into practice. The IPO Framework of LAM Teknik encompasses 74 scoring elements, categorized into 32 for inputs, 26 for processes, and 16 for outputs. This research aims to assess the validity of the IPO framework using data collected in 2022 from 263 undergraduate engineering programs. Data processing involved linear regression analysis, correlation analysis, and ANOVA. The results demonstrate the validity of the IPO framework developed by LAM Teknik, although the findings indicate challenges in assessing the outputs.

Keywords: accreditation; engineering; higher education; Indonesia

1. Introduction

Engineers have played a pivotal role in the development of civilizations and have contributed to reshaping society through a series of technological advancements that have progressively brought about improved well-being and enhanced capabilities for interacting with the environment [1]. The predictions made by Woods and Stice (2000) regarding the challenges facing engineers have been notably accurate, as corroborated by Wankat and Bullard [2]. These challenges encompass an accelerating flow of information, the proliferation of knowledge, the requirement for interdisciplinary approaches in engineering practice, the influence of global markets and competition, evident threats to the environment, the emergence of social responsibilities, the adoption of leaner corporate structures, and the rapid pace of change. Consequently, the future educational paradigm in engineering is intrinsically linked to a vision characterized by an ongoing need for adaptation, stemming from the pursuit of a more sustainable and compassionate future [1].

Engineering education integrates engineering research and education to accelerate technological and educational innovation and to improve the quality and diversity of engineering graduates entering the technical workforce [3]. Engineering education refers to acquiring knowledge, skills, and competencies related to various engineering fields. It is a formal and structured educational system that prepares individuals to become engineers and work in the diverse and rapidly evolving engineering field. Higher education in general, and engineering higher education in particular, is constantly under pressure to introduce reforms [4] and to increase quality.

The role of accreditation in higher education is to serve as a marker of a level of acceptable quality across the wide array of educational programs [5]. In developed countries, accreditation is by peers (associations), but in the developing countries, accreditation is pushed by the regulators [6]. For example accreditation process in the United States is voluntary and educational institutions or programs must request to accrediting agencies [5]. Therefore, the accreditation process becomes all the more important in the context of developing countries when compared to developed countries to ensure all institutions ensure quality in education and its delivery process [6].

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The engineering education accreditation has been a collaborative effort involving governments, engineering societies, educational institutions, and industry stakeholders. It plays a vital role in maintaining engineering programs' quality, relevance, and global recognition, ensuring that graduates are well-prepared for the challenges of a rapidly changing world.

Although accreditation is widely recognized and praised for its benefits, the system does not escape criticism. Critics have raised certain concerns, including the observation that accrediting bodies often favor an input-oriented approach despite the recent shift towards an outcome-focused approach. This preference for assessing inputs over outcomes is attributed to its relative ease of implementation. Critics argue that this emphasis on inputs has contributed to a decrease in desirable outcomes such as graduation rates, academic standards, student achievements, and has led to an increase in issues like unemployment and student loan burdens [6].

Engineering Independent Accreditation Agency (Lembaga Akreditasi Mandiri Teknik or LAM Teknik) is an independent accreditation agency entrusted with accrediting engineering programs within Indonesia. The primary objective of this research is to scrutinize the validation of LAM Teknik's Input-Process-Output (IPO) Assessment model. The central research question guiding this study is as follows: "Does LAM Teknik employ the valid IPO Assessment model?" This overarching question is dissected into several sub-questions, each aimed at providing a more comprehensive understanding of the model's validity.

RQ1: Is there any relationship between input and process?
RQ2: Is there any relationship between process and output?
RQ3: Are input, process and output has relationship with score total? Which one has the highest relationship?
RQ4: Is there any significant differences between West, Center and East Region?

This comprehensive approach aims to provide a rigorous assessment of the model's validity and its applicability across various regions.

2. Literature Review

2.1 Engineering Education Accreditation Practices in some Countries

An essential part of accreditation is the benchmarking of best practices to encourage a continuous improvement culture that leads to excellence [7]. In Australia, China, Sweden, and the United States, accreditation standards are consistently directed toward defined student learning outcomes. Notably, the requirements in each country allocate approximately equal emphasis to both technical and social capabilities within the overall set of criteria which encompass a diverse array of competencies [8]. As the most popular framework globally, the Washington Accord emphasises the role of ethical and societal considerations in the practice of engineering. Although ethics is given some importance, the study and application in UK, Ireland, France, and Switzerland were shown not to be directly linked to a broader treatment of ethical, social and global aspects in engineering [9]. Sementara itu, study from Yan, Long [10] shows that he conduct of Engineering Programmes in Malaysia, Singapore, who are also the signatories of the Washington Accord, is bounded by the accreditation of the local accreditation bodies, namely Engineering Accreditation Council (EAC) in Malaysia and Engineering Accreditation Board (EAB) in Singapore. Despite the similarities of the layout of the programme educational objectives and programme outcomes, the execution of the Outcome-Based Education in both countries varied with the different definition of the provision of evidence on how this is demonstrated in both countries. Singapore adopts a more general approach to view the general attainment of the student learning outcomes on the basis of the course, while Malaysia is practising a more microscopic methodology in measuring the individual student's attainment of learning outcomes.

Regarding the best practices, James-Okeke, Ladeji-Osias [11] stated that the importance of strategic decisions and direction to begin collaborative efforts for accreditation, including facilitating documentation, standardizing templates and assessment software. The benefit derived from these efforts is enhanced preparedness for accreditation site visits through more efficient and organized documentation practices. Moreover, Qadir, Shafi [12] emphasizes one of the best practices is the program must use a documented process that incorporates pertinent data to regularly assess student outcomes and determine the degree to which they are being met in order to be successful in receiving accreditation. Through a documented plan, the findings of these assessments of student outcomes must be used to improve the program continuously.

2.2 Engineering Education Accreditation Practices in Indonesia

Indonesia Ministry of Education and Culture (MoEC) Regulation 5/2020 stipulates that accreditation serves as an external quality assurance system within the higher education quality assurance framework. Accreditation aims to assess the eligibility of Study Programs and Higher Education Institutions based on criteria aligned with National Standards for Higher Education. It also ensures the quality of Study Programs and Higher Education Institutions, both academically and non-academically, from an external perspective, with the goal of safeguarding the interests of students and the broader community.

As prescribed by Indonesia's Law 12/2012 on Higher Education, the National Accreditation Board for Higher Education (Badan Akreditasi Nasional – Perguruan Tinggi or BAN-PT) is the singularly authorized entity tasked with executing the obligatory accreditation procedure within higher education since its inception in 1994. This is distinct from other countries where accreditation in higher education is voluntary, such as in USA [5].

Subsequent to BAN-PT's operation as the sole accrediting body in Indonesia since 1994, the Independent Accreditation Agency or Lembaga Akreditasi Mandiri (LAM) was introduced in 2021. Indonesia's Ministry of Education and Culture (MoEC) Regulation 5/2020, Article 1, defines the LAM as an institution established by the Government or the Community to independently conduct Program Study Accreditation. LAM, which operates under the purview of BAN-PT, is established for specific professional education programs. Engineering falls within the purview of one of the disciplines within the realm of applied sciences.

Engineering Independent Accreditation Agency (Lembaga Akreditasi Mandiri Teknik or LAM Teknik) is an independent accreditation agency entrusted with accrediting engineering programs within Indonesia. LAM Teknik operates under the Indonesian Engineers Association (Persatuan Insinyur Indonesia or PII). The MoEC officially announced its establishment during National Technology Awakening Day commemorating August 10, 2021. Subsequently, based on Ministerial Approval number 111125/MPK.A/HK/2021, LAM Teknik commenced its accreditation operations in April 2022.

MoEC Regulation of the Republic of Indonesia 5/2020, Article 10, stipulates that the Accreditation of Study Programs and Higher Education Institutions is conducted using accreditation instruments. These accreditation instruments are developed by either the LAM or BAN-PT, guided by the National Standards for Higher Education (SN-DIKTI). The development of accreditation instruments for the field of Engineering by LAM has adhered to the guidelines outlined in BAN-PT Regulation No. 2 of 2017 and has received approval from BAN-PT through Regulations No. 12 and 13 of 2021.

The endeavor to establish predetermined accreditation criteria by which the performance of educational institutions is evaluated is also a complex and formidable undertaking [13]. Accreditation criteria in Indonesia serve as the minimum benchmarks for accreditation, which align with SN-DIKTI. These accreditation criteria are further detailed within the assessment instruments, considering the interactions among the standards outlined in SN-DIKTI that measure the quality achievements in higher education. Since accreditation evaluates not only compliance but also the performance of study programs, the accreditation assessment considers the achievements of higher education standards established by institutions surpassing the SN-DIKTI benchmarks.

Table 1 shows the comparison of accreditation criteria between LAM Teknik and others. LAM Teknik and ABET, functioning within the framework of the Washington Accord, establish global benchmarks for engineering programs. The Washington Accord, one of seven mutual recognition agreements overseen by the International Engineering Alliance, is instrumental in this process. Signatories to the Washington Accord duly acknowledge the substantial equivalency of programs accredited by the respective signatory bodies [14]. ABET, now positioned as a professional accreditation body, extends its accreditation to encompass more than 550 programs across over 30 countries. In contrast to the majority of institutional accreditors, ABET employs outcome measures. This strategic approach ensures stakeholders, including students, employers, funding sources, and society at large, can harbor confidence in the quality standards upheld by accredited programs, thus facilitating the preparation of students for integration into a global workforce [15].

AUN-QA (version 4.0) focuses on the ASEAN region's higher education quality. The establishment of the AUN-QA commenced in 1998, with its inception as a network comprising Chief Quality Officers (CQOs) designated by AUN member universities. AUN QA serve as pivotal figures in coordinating endeavors aimed at realizing the mission of aligning educational standards and perpetually enhancing the academic quality of universities within the ASEAN region. Since its inception, AUN-QA has been proactively engaged in the promoting, developing, and implementing of quality assurance practices. These practices are underpinned by an empirical approach, wherein they are shared, tested, evaluated, and refined [16]. The AUN-QA framework, when applied at the program level, constitutes principles-based quality assurance frameworks. Notably, the criteria established by AUN-QA at the program level do not

Table. 1. Comparison between LAM Teknik and other accreditations, certifications and recognitions

LAM Teknik	AUN-QA (Ver. 4.0)	ABET	ASIIN (2022)	CDIO (Ver. 3.0)	AACSB Business (2020)
1. External Factors	2.2 Programme Structure and Content	2. Programme Educational Objectives	1. Concept, Structure & Implementation	Standard 1: The Context	Standard 1: Strategic Planning
2. Program Profile					
3. Vision, Mission, Targets, & Strategies (VMTS)	2.1 Expected Learning Outcomes			Standard 2: Learning Outcomes	
4. Governance, Administration, and Collaborations		Criterion 8. Institutional Support			Standard 8: Impact of Scholarship
5. Students	2.6 Student Support Services	Criterion 1. Students			Standard 6: Learner Progression
6. Human Resources	2.5 Academic Staff	Criterion 6. Faculty	3. Resources: Staff & Infrastructure	Standard 9: Enhancement of Faculty Competence Standard 10: Enhancement of Faculty Teaching Competence	Standard 3: Faculty and Professional Staff Resources
7. Financial Resources, Facilities, and Infrastructure	2.7 Facilities and Infrastructure	Criterion 7. Facilities Criterion 8. Institutional Support	3. Resources: Staff & Infrastructure	Standard 6: Engineering Learning Workspaces	Standard 2: Physical, Virtual and Financial Resources
8. Education	2.3 Teaching and Learning Approach 2.4 Student Assessment	Criterion 5. Curriculum	2. Examinations: Systems, Policy & Implementation 5. Documentation & Transparency	Standard 3: Integrated Curriculum Standard 4: Introduction to Engineering Standard 5: Design-Implement Experiences Standard 7: Integrated Learning Experiences Standard 8: Active Learning Standard 11: Learning Assessment	Standard 4: Curriculum Standard 6: Learner Progression Standard 7: Teaching Effectiveness and Impact
9. Research					Standard 9: Engagement and Societal Impact
10. Community Engagement					Standard 9: Engagement and Societal Impact
11. Outcomes of Education, Research and Community Engagement	2.8 Output and Outcomes	Criterion 3. Student Outcomes			Standard 7: Teaching Effectiveness and Impact
12. Quality Assurance		Criterion 4. Continuous Improvement	4. Quality Management: Monitoring & Continuous Improvement	Standard 12: Program Evaluation	Standard 5: Assurance of Learning
13. Sustainable Development					

concentrate on specific disciplines. Instead, they are directed towards assessing the conditions that guarantee the quality of a given study program [17]. Faculty qualifications, student outcomes, and continuous improvement processes are key areas of evaluation.

ASIIN (version 2022), originating in Germany, aligns with European Standards and Guidelines for quality assurance. ASIIN serves as the European certification agencies for engineering education and is a member in the Washington Accord. Consequently, individuals graduating from fields successfully accredited by ASIIN attain the Engineer qualification not only within the European Union but also in the United States, Canada, Australia, Japan, and other countries signatory to the "Washington Accord" [18]. The accreditation process administered by ASIIN critically assesses the rationale and effectiveness of a program within the study curriculum. The pivotal focus of this evaluation lies in the efficient realization of the objectives set forth by the organization itself [19]. The criteria involve thoroughly evaluating curriculum design, research activities, and integrating theoretical and practical elements.

CDIO (version 3.0) stands out for its unique approach to accreditation, focusing on Conceive, Design, Implement, and Operate. The criteria revolve around project-based learning, ensuring students acquire hands-on experience and develop problem-solving skills. Collaboration with industry and the relevance of projects to real-world challenges are key components. The CDIO (Conceive-Design-Implement-Operate) initiative constitutes an educational framework that underscores engineering fundamentals [20]. Importantly, it is essential to note that CDIO is an educational framework and does not represent a prescribed set of accreditation requirements [21].

In the field of business education, AACSB Business (version 2020) sets high standards. AACSB accreditation is widely recognized as the preeminent standard for accrediting business schools, often considered the "gold standard." It is commonly acknowledged for enhancing student preparedness, elevating faculty quality, improving job placement rates, and optimizing the internal operations and strategic planning processes of business schools [22]. The processes and accreditation procedures implemented by AACSB are associated with advantageous outcomes, including increased student retention, the attraction of high-quality faculty, improved job placement rates, and positive community perceptions regarding the institution's role as a provider of quality business education [23].

The accreditation assessment criteria for LAM Teknik's study programs are categorized into input, process, and output aspects. For each assessment criterion, indicators and evaluation elements have been devised. The accreditation assessment criteria comprise 74 scoring elements categorized into 32 scoring elements for input, 26 scoring elements for process, and 16 scoring elements for output, as shown in Fig. 1. The weightage assigned to the input, process, and output aspects varies, with the input aspect carrying a weight of 29.5, the process aspect 34.8, and the output aspect 35.7.

The assessment is conducted based on the Self-Evaluation Report (Laporan Evaluasi Diri or LED) and the Study Program Performance Report (Laporan Kinerja Program Studi or LKPS), which contain quantitative performance indicators reflecting compliance with and/or surpassing the SN-DIKTI. Within the process of accrediting study programs, each criterion is further broken down into a set of elements with indicators that must be objectively demonstrated by both the Higher Education Institution (UPPS) and the study program. Each item in the accreditation proposal for study programs is quantitatively assessed on a scale ranging from Score 0 to 4. Score 0 represents the lowest score, which increases with the improving quality of the item being assessed, with a maximum score of 4.

Furthermore, the accreditation score (Nilai Akreditasi or NA) is calculated cumulatively, taking into account the weight assigned to each evaluation item, with the calculation as follows:

$$NA = \Sigma\, score_i \times weight_i \text{ where } \Sigma\, weight_i = 100.$$

In general, the accreditation assessment by LAM Teknik relies on self-evaluation reports produced by each individual study program. The self-evaluation report consists of five sections, namely External Conditions, Program Profile, Criteria, Quality Assurance, and Sustainable Development Program. In the criteria section, nine criteria established by BAN-PT are utilized, which hold national validity across Indonesia.

3. Methods

This research employs a statistical evaluation as quantitative approach to address research ques-

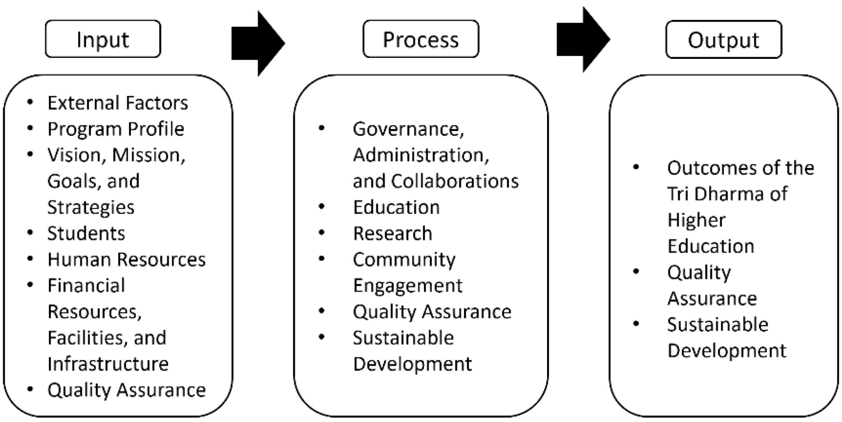

Fig. 1. Input, process and outputs' score elements and criteria.

tions and accomplish research objectives. Statistical evaluation aims to describe relationships between two or among several variables, one of which is regression analysis, an essential statistical method for data analysis, enabling the identification and characterization of relationships among factors [24]. This study employed linear regression analysis and correlation analysis to address the RQ1, RQ2, and RQ3 concerning the relationships among the input, process, output variables, and the total score. This approach also aligns with Borrego, Douglas [25], who states that linear regression can serve as a robust statistical technique in research attempts to investigate relationships between variables. The correlation analysis provide correlation coefficients which shows the information about the strength and direction of a relationship between two variables [26]. Table 2 shows the level of strength of correlation.

To address RQ4, which aims to examine significant differences among the West, Central, and East regions, an analysis of variance (ANOVA) was conducted within this study. Given that the accreditation scores as the dependent variable examined in this research are continuous, the statistical analysis method employed is Analysis of Variance (ANOVA). The purpose of utilizing ANOVA is to ascertain whether a statistically significant difference exists between the mean scores of distinct regions [25]. Analysis of variance (ANOVA) is a statistical tool to detect differences between experimental group means. ANOVA is based mathematically on linear regression and general linear models that quantify the relationship between the dependent and independent variables [27].

The dataset utilized in this study consists of accreditation scores obtained from 263 undergraduate engineering programs, collected in 2022. The study programs were grouped into three regions: the West region with 65 programs, the Central region with 166 programs, and the East region with 32 programs. Geographically, the West region encompasses Sumatra Island, the Central region encompasses Java and Kalimantan Islands, while the East region encompasses Sulawesi, Maluku, Nusa Tenggara, and Papua Islands.

Table 2. Level of strength of correlation [26]

Size of R	Interpretation
0.90 to 1.00	Very high correlation
0.70 to 0.89	High correlation
0.50 to 0.69	Moderate correlation
0.30 to 0.49	Low correlation
0.00 to 0.29	Little if any correlation

4. Results

4.1 Relationship Between Input and Process

In the context of regional regression analysis, three distinct regression equations were derived to model the relationships between certain variables in different geographic regions (Fig. 2). In the West region, the regression equation was expressed as y = 0.89x + 23.681, where 'y' represents process as dependent variable and 'x' is input as independent variable. The coefficient of determination, denoted as R square, was determined to be 0.5622, indicating a moderate level of explanatory power in this model. The R-squared value indicates that approximately 0.5622 of the variability in the dependent variable 'y' in the West region can be explained by the independent variable 'x'. In other words, leaving 43.78% unexplained variation. The coefficient of correlation (R) with a value of 0.7497 between input and process variables in the West region indicates a strong positive relationship.

Similarly, in the Central region, the regression equation took the form y = 0.8035x + 35.038, and its associated R square value was computed as 0.598. The slope of 0.8035 indicates that for every unit increase in 'x', 'y' is expected to increase by 0.8035 units, assuming a linear relationship. The intercept of 35.038 represents the estimated value of 'y' when 'x' is zero. The R-squared value of 0.598 suggesting that the model in the Central region explains approximately 59.8% of the variation in 'y'. In other words, leaving 40.2% unexplained variation. The coefficient of correlation (R) with a value of 0.7733 between input and process variables in the Central region indicates a very strong positive relationship.

Lastly, in the East region, the regression equation was represented as y = 0.925x + 22.454, with an R square value of 0.6347, indicative of a relatively robust relationship between the variables under consideration. East region also have linear regression equation. The slope of 0.925 implies that a one-unit increase in 'x' results in a 0.925-unit increase in 'y'. The intercept of 22.454 represents the estimated 'y' value when 'x' is zero. The R-squared value of 0.6347 is the highest among the three regions, indicating that the model in the East region explains approximately 63.47% of the variation in 'y'. This suggests a relatively strong linear relationship between 'x' and 'y' in the East region compared to the other regions. In other words, leaving 36.53% unexplained variation. The coefficient of correlation (R) with a value of 0.7966 between input and process variables in the East region demonstrates a very strong positive correlation.

These regression equations and R-squared values provide insights into how well the linear models fit

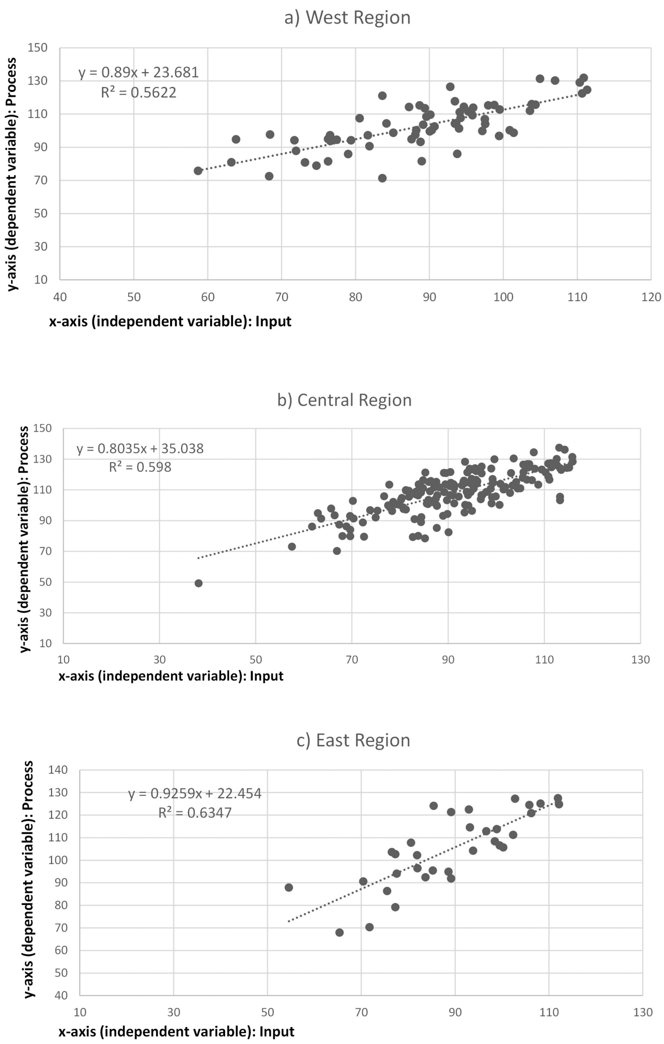

Fig. 2. Results of Linear Regression Analysis Between Input and Process. (a) West Region, (b) Central Region, (c) East Region.

the data in each geographic region. The R-squared values indicate the proportion of the variance in the dependent variable that can be explained by the independent variable(s), with higher values suggesting stronger relationships. These findings illustrate variations in the strength of the regression models across different geographical areas. The correlation analysis results also indicate strong positive correlations between input and process variables in all three regions (Table 3). Improvements in input variables have a substantial positive impact on process variables.

4.2 Relationship Between Process and Output

In the context of regional regression analysis, three distinct regression equations were derived to model relationships between certain variables across different geographical regions (Fig. 3). In the West region, the regression equation took the form y = 0.4411x + 53.927, where 'y' signifies output as the dependent variable, and 'x' represents process as the independent variable. The coefficient of determination, denoted as R square, was calculated to be 0.0624, indicating a relatively low degree of explanatory power within this model. This low R^2 value suggests that the linear relationship described by the equation does not capture much of the variation in 'y'. The coefficient of correlation (R) with a value of 0.2497 between process and output variables in the West region indicates a little if any correlation.

Similarly, in the Central region, the regression equation was expressed as y = 0.9512x + 2.0199, and the associated R square value was computed as 0.2045, This means that approximately 20.45% of the variability in 'y' is explained by 'x'. it indicates that there are still substantial unexplained factors influencing 'y' in this region. The coefficient of correlation (R) with a value of 0.4522 between process and output variables in the Central region indicates a low positive relationship.

Table 3. Results of Correlation Analysis Between Input and Process in All Regions

Region	Coefficient correlation	Interpretation
West	0.7497	High correlation
Central	0.7733	High correlation
East	0.7966	High correlation

Table 4. Results of Correlation Analysis Between Process and Output in All Regions

Region	Coefficient correlation	Interpretation
West	0.2497	Little if any correlation
Central	0.4522	Low correlation
East	0.4304	Low correlation

Lastly, in the East region, the regression equation was represented as 0.8198x + 3.2416, with an R square value of 0.1853, indicative of a moderate level of explanatory strength. The low R^2 value of 0.1853, indicating that only around 18.53% of the variability in 'y' is accounted for by 'x'. This suggests that the linear model is not capturing a significant portion of the variation in the dependent variable. The coefficient of correlation (R) with a value of 0.4304 between process and output variables in the East region indicates a low positive relationship.

A low degree of explanatory power in a regression equation, as indicated by a low R-squared (R^2) value, suggests that the independent variable(s) in the model are not very effective at explaining the variability in the dependent variable. Low R^2 values can result from various factors, including the presence of other unmeasured variables that influence 'y', nonlinearity in the relationship, or issues with data quality. The correlation analysis results also indicate weak and moderate positive correlations

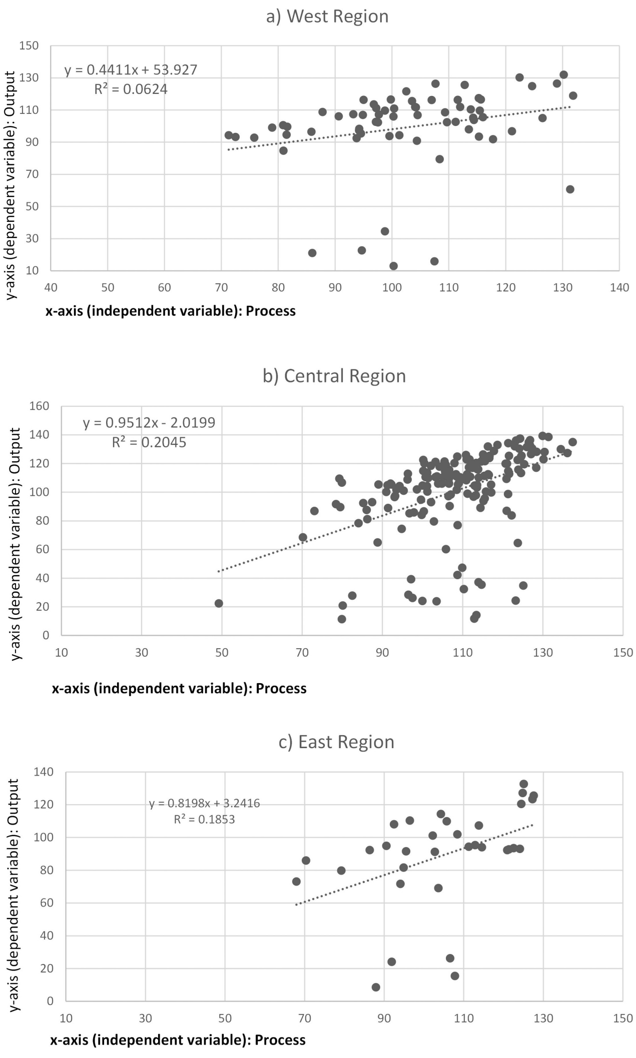

Fig. 3. Results of Linear Regression Analysis and Correlation Analysis Between Process and Output. (a) West Region, (b) Central Region, (c) East Region.

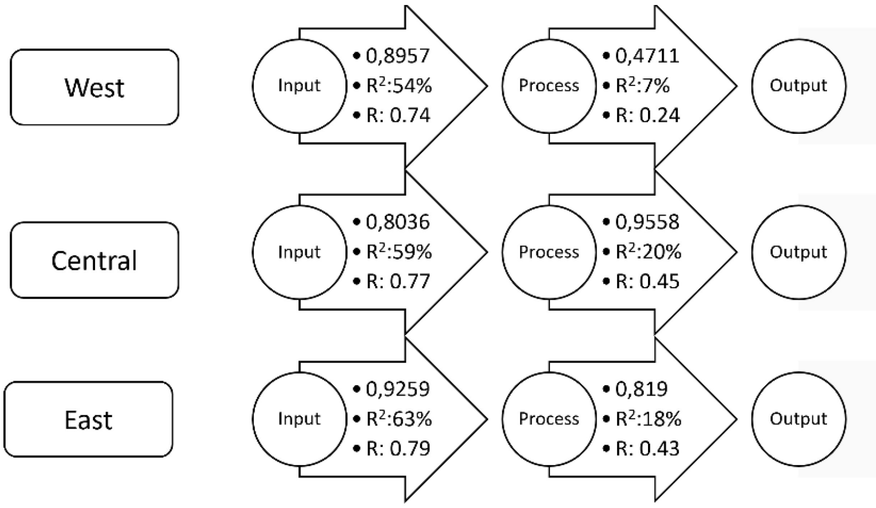

Fig. 4. Summary of Linear Regression Analysis and Correlation Analysis Results Between Input, Process and Output for All Regions.

between process and output variables in all three regions (Table 4). Improvements in process variables may not have a substantial positive impact on output variables. The summary of Linear Regression and Correlation Analysis are shown in Fig. 4.

4.3 Relationship Between Input, Process and Output with Total Score

The results show the relationship between input and total scores across different geographical regions, West, Central, and East regions (Fig. 5). This analysis is conducted through the utilization of correlation coefficients (R values) as a statistical measure to quantify the strength and direction of this relationship. In the West region, the calculated correlation coefficient (R-value) stands at 0.78, indicating a positive high correlation between the input variables and the total scores. In the Central region, the correlation coefficient (R-value) is at 0.83. Lastly, in the East region, the correlation coefficient (R-value) is reported as 0.84. The results show varying degrees of positive correlation between input variables and total scores across the West, Central, and East regions, with the East region exhibiting the strongest association, as reflected by its higher correlation coefficient of 0.84.

The analysis of the relationship between process and the total score within different geographical regions reveals notable correlation coefficients (R values). In the West region, the correlation coefficient is calculated at 0.72, signifying a high positive correlation between the process and the total score. In the Central region, the correlation coefficient stands at 0.78, and similar to East region, the R-value of 0.78 is observed, emphasizing a high positive correlation between process and the total score. These findings shed light on the relationship between process and total score, which has a high positive correlation in three regions.

The investigation into the relationship between the output and the total score, conducted across different geographical regions, reveals notable correlation coefficients (R values). In the West region, a correlation coefficient of 0.82 is computed, indicating a high positive correlation between output and the total score. In the Central region, the correla-

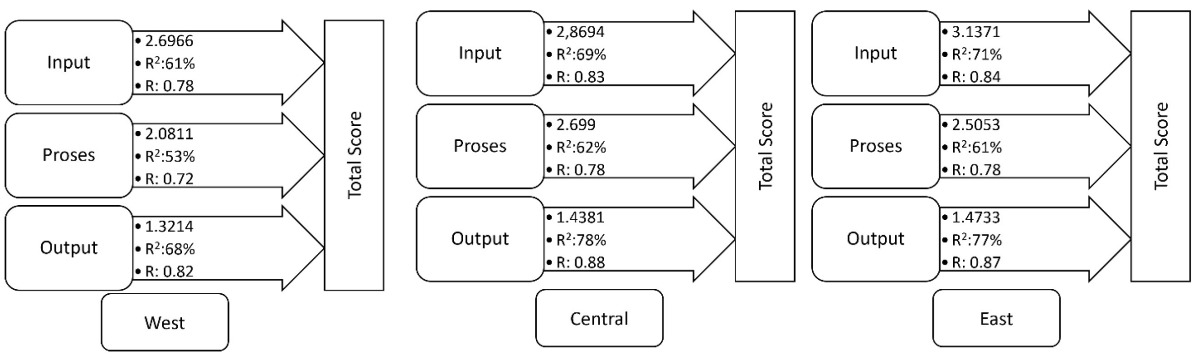

Fig. 5. Results of Linear Regression Analysis and Correlation Analysis Between Input, Process and Output to Total Score. (a) West Region, (b) Central Region, (c) East Region

tion coefficient is 0.88, underscoring a high positive relationship between the output and the total score. Likewise, the East region exhibits a high positive correlation, with an R-value of 0.87, further emphasizing the connection between the "output" variable and the total score. Collectively, these findings elucidate a high degree of positive correlation between the "output" variable and total scores across distinct geographical regions.

4.4 Differences Among West, Central and East Region

To determine whether there is a significant difference among the three results, a statistical test, analysis of variance (ANOVA) has been conducted to assess whether the differences in the R-squared values are statistically significant. ANOVA can help determine if there are significant variations in the explanatory power of the regression models across the different geographic regions. The results of the ANOVA will tell whether there is a statistically significant difference in the R-squared values among the regions. If the p-value is less than your chosen significance level, it suggests that at least one region's R-squared value is significantly different from the others. Statistical significance doesn't necessarily imply practical significance. Even if the ANOVA indicates a significant difference, researcher should also consider the practical importance and context of these differences when interpreting the results.

Null Hypothesis (H0): There is no significant difference in the means of the R-squared values among the West, Central, and East regions.

Alternative Hypothesis (Ha): There is a significant difference in the means of the R-squared values among the West, Central, and East regions.

In null hypothesis significance testing, data analysis is required to select a critical significance level denoted as "alpha," represented as α. This alpha level serves as a threshold to determine whether a specific dataset provides evidence for a particular effect. In many academic disciplines, the conventional practice has set α equal to 0.05 as the standard significance cutoff [28].

The analysis employed an Analysis of Variance (ANOVA) test to assess whether there exists a statistically significant difference in the means of the R-squared values across the West, Central, and East regions (Table 5).

The results of the ANOVA test revealed an F-statistic (F) of 2.442429 and a corresponding p-value of 0.088942. In comparison, the critical F-value (F critical) at the chosen significance level was determined to be 3.030516. Interpreting these findings, as the p-value (0.088942) is greater than the selected significance level ($\alpha = 0.05$), there is insufficient evidence to reject the null hypothesis (H0: There is no significant difference in the means of the R-squared values among the West, Central, and East regions).

5. Discussion

According to the IPO framework, the Input aspect consists of External Factors, Program Profile, VMTS (Vision, Mission, Targets and Strategies), Student, Human Resources, Financial, Facilities and Infrastructure, and Quality Assurance. Meanwhile, the Process aspect encompasses Governance, Administration and Collaboration, Education, Research and Community Engagement, Quality Assurance, and Sustainable Development. Since Quality Assurance (QA) is included in both the Input and Output aspects, it is not considered in the subsequent analysis concerning the correlation between Input and Output.

The results of the correlation analysis between Input and Output aspects indicate a high correlation across all regions (West, Central, and East). This implies that the criteria within the Input aspect

Table 5. ANOVA test

Anova: Single Factor						
SUMMARY						
Groups	**Count**	**Sum**	**Average**	**Variance**		
West	65	19148.47	294.5918	1399.683		
Central	166	50371.41184	303.4422	1974.785		
East	32	9185.74	287.0544	2201.819		
ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Between Groups	9087.2585	2	4543.629	2.442429	0.088942*	3.030516
Within Groups	483675.623	260	1860.291			
Total	492762.882	262				

* Not significant when alpha 0.05.

positively influence the criteria within the Process aspect. Based on the data, the average score for the Input aspect is 3.2 out of a maximum score of 4.0. This generally suggests that engineering programs in Indonesia have good Input characteristics. Furthermore, the average score for the Process aspect is also 3.2 out of a maximum score of 4.0. Therefore, there is a logical relationship between the Input and Process aspects.

For example, upon closer examination of each criterion within each aspect, this logical relationship can be observed, such as the relationship between VMTS (Input) and Governance (Process). Based on the data, the average VMTS (Input) score is 3.11, while the average Governance (Process) score is 3.17. The better a program develops its VMTS, the more effectively Governance processes are carried out. A logical connection is also evident for other criteria within the Input and Process aspects, such as Student, Human Resources, Financial, Facilities, and Infrastructure (Input) influencing Education, Research, and Community Engagement (Process). Based on the data, the average score for Student (Input) is 2.8, while the average score for Education (Process) is 2.9. When the academic quality of admitted students improves, the Education process also tends to improve accordingly.

In contrast to the high correlation between Input and Process aspects, the correlation between the Process and Output aspects is notably low. Several factors contribute to this, which are related to the lower values of Output compared to Process. Firstly, the data includes newly established academic programs (academic programs seeking accreditation in 2022 that were established after 2017). Two elements of the Output score are likely to be low for these newly established programs, potentially receiving a score of 0. The first element pertains to the Outputs and Achievements in education, research and community engagement, as some assessment criteria are related to graduates. Since newly established programs do not have graduates at the time of accreditation, they are assigned a score of 0.0. The second potential reason for the low correlation between the Process and Output aspects is the possibility of errors in determining assessment criteria, particularly those associated with the Output aspect. Addressing this issue would require a more in-depth analysis based on a longer dataset.

Based on the literature, accrediting bodies often tend to favor an input-oriented approach, despite the recent trend towards an outcome-focused approach [6]. This tendency is also evident in the IPO framework adopted by LAM Teknik. In this framework, the Input aspect comprises 32 score elements, the Process aspect includes 26 score elements, while the Output aspect contains only 16 score elements. This disparity may be attributed to the relative ease of implementing assessments focused on inputs as opposed to outcomes [6]. However, it is worth noting that the IPO framework of LAM Teknik has been shifting towards an outcome-focused approach, as evidenced by the higher weighting given to the Output aspect, with a score of 35.7 (for 16 score elements) compared to the Input aspect's score of 29.5 (for 32 score elements).

Based on the R-squared values, an anomaly is observed when examining the results per region, which have varying data quantities. Specifically, there are 65 programs in the West region, 166 programs in the Central region, and 32 programs in the East region. Interestingly, the R-squared value for the East region stands at 0.6347, the highest among the three regions, surpassing the West region's R-squared value of 0.5622 and the Central region's value of 0.598. Normally, in statistical terms, a larger dataset tends to yield more robust results. This discrepancy might be attributed to potential variations in assessors across regions, leading to scoring bias. The R-squared value of 0.6347 in the East region indicates that the model explains approximately 63.47% of the variation in 'y,' signifying a relatively strong linear relationship between 'x' and 'y' compared to the other regions, while leaving 36.53% of the variation unexplained. Several factors could contribute to this lower explanatory power, including unaccounted-for variables, non-linear relationships, or measurement errors.

Tables 6, 7, and 8 encapsulate research questions RQ1-RQ4 and the findings of this study.

Table 6. Summary of RQ1 and RQ2

	Research Question	**Region**	**Coefficient correlation**	**Interpretation**
RQ1	Is there any relationship between input and process?	West	0.7497	High correlation
		Central	0.7733	High correlation
		East	0.7966	High correlation
RQ2	Is there any relationship between process and output?	West	0.2497	Little if any correlation
		Central	0.4522	Low correlation
		East	0.4304	Low correlation

Table 7. Summary of RQ3

	Research Question	Region	Coefficient correlation		
			Input to Total Score	Process to Total Score	Output to Total Score
RQ3	Are input, process and output has relationship with score total? Which one has the highest relationship?	West	0.78	0.72	0.82
		Central	0.83	0.78	0.88
		East	0.84	0.78	0.87

Table 8. Summary of RQ4

		F score	F critical	Interpretation
RQ4	Is there any significant differences between West, Center and East Region?	2.44	3.03	Insufficient evidence to reject the null hypothesis (H0: There is no significant difference in the means of the R-squared values among the West, Central, and East regions.)

6. Conclusions

Developing specified accreditation criteria to assess educational institutions' performance is challenging. LAM Teknik has established accreditation assessment criteria based on the Input-Process-Output (IPO) structure. The purpose of this study is to evaluate the IPO framework's validity utilizing data gathered from 263 undergraduate engineering programs in 2022. ANOVA, correlation analysis, and linear regression analysis have been employed to analyze the data.

The results of the correlation analysis revealed a high positive relationship between the input and process aspects across all three regions, signifying that improvement in the input aspect significantly benefits the process aspect. Moreover, the correlation analysis also uncovers a low positive relationship between the process and output aspect in these regions, suggesting that improvements in the process aspect may exert a low positive influence on the output aspect. Additionally, the relationships observed between input, process, output, and scores exhibit strong positive correlations across the entire geographical scope, underscoring the constructive impact of endeavors to enhance input, process, and output on the overall score improvement. These results affirm the validity of the IPO framework formulated by LAM Teknik, although they underscore the complexity of assessing outputs.

Moreover, a statistical assessment using ANOVA was performed to ascertain any notable differences among the three regions. The results of the ANOVA analysis do not present substantial statistical support for the hypothesis that a significant difference exists among the West, Central, and East regions. Therefore, it is recommended that future research endeavors delve further into the low correlation between the Process and Output aspects. Addressing this issue would necessitate a more comprehensive examination of an extended dataset.

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