

Accreditation in Engineering Education: Findings from Selected Asia-Pacific Countries

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***Abstract:** It has been observed that the current accreditation models implemented in engineering education worldwide are non-uniform, non-transparent and lacking a systematic approach. This paper aims to explore the existing accreditation systems in engineering education implemented in the Asia-Pacific countries. The paper presents fieldwork data analysis of accreditation processes collected from six institutions from Australia, Malaysia and India. The findings of the data analysis support the hypotheses on engineering accreditation. Important findings and key limitations of the existing accreditation models are presented and briefly discussed in this paper.*

Introduction

The recent growth of engineering education has put pressure on the quality in order to produce competent global engineering professionals. Accreditation, being the most influential tool of quality assurance, can be used to enhance the engineering education and engineering profession. The accreditation in engineering and technology commenced voluntarily with the help of the Accreditation Board for Engineering and Technology (ABET) in the United States. Various national and regional accreditation authorities have also developed accreditation systems for the assessment of engineering education. The existing accreditation systems implemented worldwide are non-uniform and often, non-systematic. Furthermore, the accreditation criteria developed and implemented by various national and regional accreditation bodies do not assess all of the essential elements of the educational process cycle. Hence there are increasing concerns about the proper assessment of engineering graduate attributes as well as difficulties in the mutual recognition and mobility of engineering professionals. Although, various accreditation models have been developed to assess engineering courses, most of these are non-uniform, too complex, non-transparent and lacking the systematic approach. Most of these accreditation models cater for the national and regional engineering education system. A review of the literature shows that most of the accreditation processes developed to improve the quality of engineering education do not focus on all three components of the educational process cycle, ie. input, teaching/learning and output. Moreover, in developed countries the emphasis on the accreditation process has recently moved to being ‘outcomes’ based or ‘output’ focused. Based on the literature review and the review of existing accreditation models in various countries, the following hypotheses are formulated.

- There is a lack of uniformity in the accreditation processes.
- The accreditation criteria developed and applied neglects the educational process cycle as a whole.
- There is no clear-cut and comprehensive assessment of engineering graduate attributes.

The authors have proposed a global accreditation model to accredit engineering programs internationally. Based on this model, fieldwork data has been collected using the criteria developed during the research project in Monash University. The collected data has been analysed to test the hypotheses. The key findings of the data analysis are presented and discussed in the following sections of the paper.

The development of a global accreditation model

Accreditation improves institutional prestige and academic standards in the global environment. The accreditation for engineering programmes can be voluntary or compulsory and divided into two main types, namely; institutional accreditation and programme accreditation. The accreditation process can generally be based on the following step-by-step elements as shown in Figure 1.

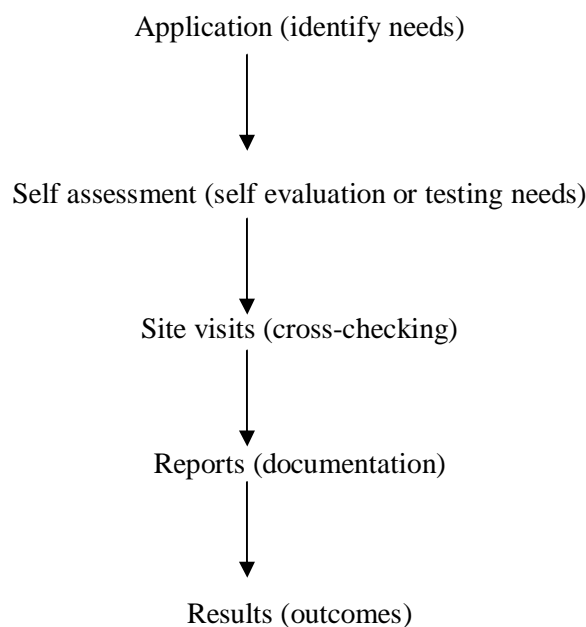


Figure 1: Outline of the accreditation process.

The recent literature shows that numerous countries do not have a formal accreditation system or a specific accreditation process for engineering education and where there is an existing accreditation system it lacks a systematic approach (Augusti, 2007). A few examples have been found for regional accreditation models, such as, for example, EurACE in Europe, however these developments have been very slow. Furthermore, a literature search did not show any evidence of the development of a trans-national or international accreditation model in engineering. Therefore, a systematic, transparent, open-ended and well-structured *Global Accreditation Model* in engineering education is required which can be used to assess global professional skills and competencies of engineering graduates. This approach will also help in mutual recognition and mobility of engineering professionals worldwide.

In the first phase of the project a global accreditation model has been developed, the design of which is based on the educational process cycle as shown in Figure 2. The accreditation process must consider all three parts of the educational process cycle (Patil & Codner, 2007). In the second phase of the project the data has been collected and analysed to test the hypotheses which are listed above. A semi-structured survey format consisting of a mapping matrix of accreditation criteria was chosen as the method of data collection. The findings from the literature review of the existing accreditation systems implemented in various countries were used to develop the assessment criteria of a Global Accreditation Model. Feedback from accreditation experts of national accreditation agencies during several onsite visits also helped the design and development of the model.

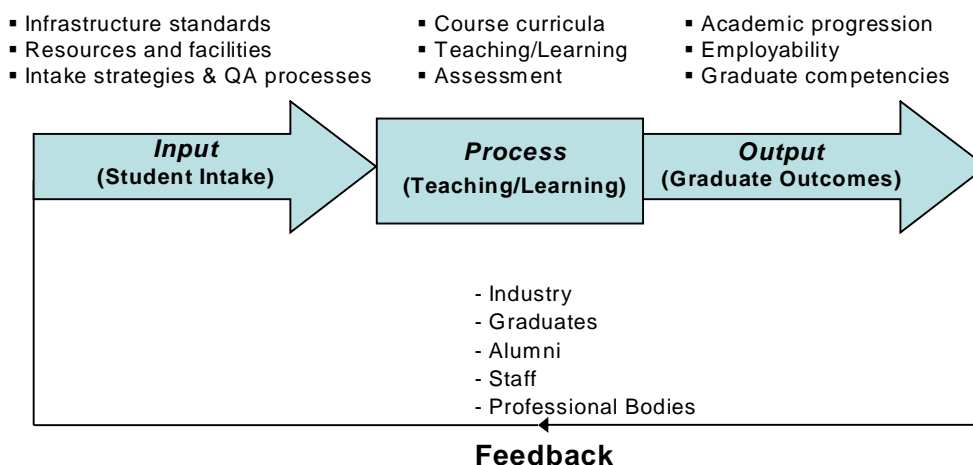


Figure 2: The Educational Process Cycle used for the development of Global Accreditation Model

The design of a global accreditation model includes a strategy for the assessment of a comprehensive educational process in three different groups or parts as outlined in Figure 2 of the educational process cycle. The key elements of each part of the process cycle are as below:

GROUP A: Input (Student Intake)

- 1) Infrastructure standards
- 2) Resources and facilities
- 3) Intake strategies and QA processes

GROUP B: Process (Teaching/Learning)

- 1) Engineering course curricula
- 2) Teaching/Learning processes
- 3) Assessments

GROUP C: Output (Graduate Outcomes)

- 1) Academic progression
- 2) Employability
- 3) Graduate competencies

Every element is again divided into sub elements and the sub element is further assigned with appropriate criteria. For example, one of the key elements in the Section B1 of the Teaching/Learning Process is Engineering Course Curriculum. This consists of three sub-elements and their criteria as shown in Table 1.

Table 1: Mapping of the accreditation criteria using accreditation elements and parameters.

Key Element: Engineering Course Curriculum (B1)	
Sub Elements	Accreditation Criteria
Program/course structure and description (B11)	Program goals and objectives (B111)
	Specific unit/subject goals and outcomes (B112)
	Title and award (B113)
	Course duration and completion criteria (B114)
Curriculum implementation (B12)	Teaching modes and strategies (B121)
	Curriculum implementation strategies (B122)
	Contact hours/study hours (for classroom and laboratory) (B123)
Curriculum review (B13)	Program/unit alignment with graduate attributes (B131)
	Professional practice (B132)
	Curriculum review and feedback strategies (B133)

A standard Global Performance Criteria and Evidence Guide is developed using accreditation parameters. The entire chart consists of 10 elements, 30 sub elements and 100 parameters for the global accreditation model.

Fieldwork

In the second phase of the research project, fieldwork was conducted at six engineering institutions in Australia, Malaysia and India. Data was collected from civil and mechanical engineering disciplines of these six institutions using the survey format developed in the first phase, based on the framework of a global accreditation model. The targeted respondents were mostly accreditation experts/officers, quality managers and academics looking after the accreditation of engineering programmes of their institutions. The respondents were requested to enter their responses on the performance criteria mapping chart. The performance criterion for each parameter is verified with two types of check lists of evidence; documentary and material or physical (actual). The developed mapping charts of evidence guide were entered with a score/ranking against the performance criteria using the lists of evidence. The ratings derived are based on a five-point Likert type scale, as shown below:

1. Poor
2. Below Average
3. Average (Satisfactory)
4. Above Average
5. Superior (Excellent)

The respondents scored items on the evidence guide chart. Ratings from the evidence guide of each institution provided data on the accreditation parameters and elements, which was then used for testing of the hypotheses. The scores obtained from the rankings were then entered as a data set into SPSS for further analysis. This data set has been used to test the significance of the group differences, ie. input, process and output.

Data Analysis

The collected data was analysed using the Statistical Product and Service Solutions Program (SPSS) (formerly Statistical Package for the Social Sciences). Descriptive statistics, i.e. the basic features of the data, were used to examine the results, which provide simple summaries about the samples and measures. Data related to the three parts of the educational process cycle, eg. Input, teaching/learning and output, in different institutions and countries were analysed for difference using SPSS. The data analysis is performed for all possible combinations as explained below.

Table 2 summarises the data for two independent variables (that is for Group of accreditation parameters and Institutions) and provides means, standard deviations (SD) and sample size (N) of the dependent variable *Score* (accreditation performance) for each combination of levels of the independent variables (Input, Teaching/learning and Output). In the data sample, the dependent variable (*Score*) is on the scale 1: Poor; 2: Below Average; 3: Average (Satisfactory); 4: Above Average; 5: Superior (Excellent).

The results from the analysis strongly support the hypotheses as described below.

Hypothesis 1: There is a lack of uniformity in the accreditation processes in various Asia-Pacific countries.

Table 3 presents summary data for the two independent variables (that is for Group of accreditation parameters and Countries) and provides means, standard deviations (SD) and sample size (N) of the dependent variable *Score* (accreditation performance).

The Analysis of variance (ANOVA) was used to examine whether there is significance or individual difference among the means of the groups. The output from 2-way ANOVA showed an interaction effect and the overall model is statistically significant ($F = 5.003$, $p = 0.000$). It was found that the interaction between Group (of accreditation parameters) and Institutions is statistically significant ($F = 3.601$, $p = 0.000$). In other words, there is a significant difference in the accreditation parameters (Groups) on the score (performance) for each institution. Therefore there is genuinely a significant

difference between accreditation parameters (Groups) in their performance level (Score) with their institutions.

Table 2: Data summary showing means and standard deviations for all engineering institutions (dependent variable score).

Group	Institution*	Mean	Std. Deviation	N
Input	AUS1 (Australia)	4.53	.819	30
	MY1 (Malaysia)	4.10	.845	30
	MY2 (Malaysia)	3.63	.928	30
	IND1 (India)	3.83	1.020	30
	IND2 (India)	3.90	.845	30
	IND3 (India)	4.37	.964	30
Teaching/learning	AUS1 (Australia)	4.10	.885	30
	MY1 (Malaysia)	3.67	.711	30
	MY2 (Malaysia)	4.43	.568	30
	IND1 (India)	3.83	1.262	30
	IND2 (India)	3.87	.571	30
	IND3 (India)	3.43	1.455	30
Output	AUS1 (Australia)	3.98	.862	40
	MY1 (Malaysia)	3.85	.662	40
	MY2 (Malaysia)	3.55	.639	40
	IND1 (India)	3.63	1.213	40
	IND2 (India)	3.33	.474	40
	IND3 (India)	3.20	1.556	40
Total	AUS1 (Australia)	4.18	.881	100
	MY1 (Malaysia)	3.87	.747	100
	MY2 (Malaysia)	3.84	.813	100
	IND1 (India)	3.75	1.167	100
	IND2 (India)	3.66	.685	100
	IND3 (India)	3.62	1.448	100

*For purposes of confidentiality, institutions are identified only as AUS1, MY1, MY2, IND1, IND2 and IND3.

Out of many different kinds of post-hoc tests to examine which means are different from each other the Scheffe's test was performed to compare all pairs of group means. Scheffe's test, used with unequal sample sizes, is a method of multiple comparisons which can be used for not only pair wise comparisons but all possible linear combinations of group means (Carver & Nash, 2006). Table 4 shows the results of Scheffe tests for the combination of three countries, that is, an output obtained using the Scheffe test for the multiple comparisons of accreditation performance between three countries; Australia, Malaysia and India. The results show that there is a significant difference in the accreditation performance between Australia, Malaysia and India. ($p= 0.001, 0.000$ and 0.028). These results are shown in the profile plots (Figures 3 and 4) and described below.

Table 3: Data summary showing means and standard deviations for three countries (dependent variable score).

Country	Group	Mean	Std. Deviation	N
Australia	Input (A)	4.53	.819	30
	Teaching/Learning (B)	4.10	.885	30
	Output (C)	3.98	.862	40
Malaysia	Input (A)	3.87	.911	60
	Teaching/Learning (B)	4.05	.746	60
	Output (C)	3.70	.664	80
India	Input (A)	4.03	.965	90
	Teaching/Learning (B)	3.71	1.164	90
	Output (C)	3.38	1.175	120

Table 4: Scheffe test for the multiple comparisons between the countries for the accreditation performances.

(I) Country	(J) Country	Mean Difference (I-J)	Sig. (p)
Australia	Malaysia	.33(*)	.001
	India	.50(*)	.000
Malaysia	Australia	-.33(*)	.001
	India	.18(*)	.028
India	Australia	-.50(*)	.000
	Malaysia	-.18(*)	.028

*The mean difference is significant at the .05 level.

Figure 3 shows the profile plot of all six institutions for the accreditation performance in which, the group means of accreditation performance (A, B, C) are plotted against the institutions. It is clear from the graph that all six institutions have non-uniform accreditation performances. The highest accreditation performance score is slightly greater than 4.5 (Australian institution) for the input group of accreditation parameters, whereas the lowest accreditation performance score is less than 3.25 (Indian institution for output). The figure also indicates that there is a substantial difference for the accreditation performance between the input and the output groups of the accreditation parameters. The accreditation performance is high for the Australian institution when compared with the performance of Malaysian and Indian institutions. Interestingly, the accreditation performance for the Malaysian and Indian institutions show considerable fluctuations with the accreditation performance reversing across sub-groups. Figure 4 is a graph for the accreditation performance of all six institutions in which, the sub-group means (A11, A12, ...B11, B12..) of accreditation performance are plotted against all institutions. The graph shows zigzag curves for all six institutions and clearly indicates that there is no uniformity in the accreditation process. That means, the accreditation performances for all institutions and for all countries vary significantly.

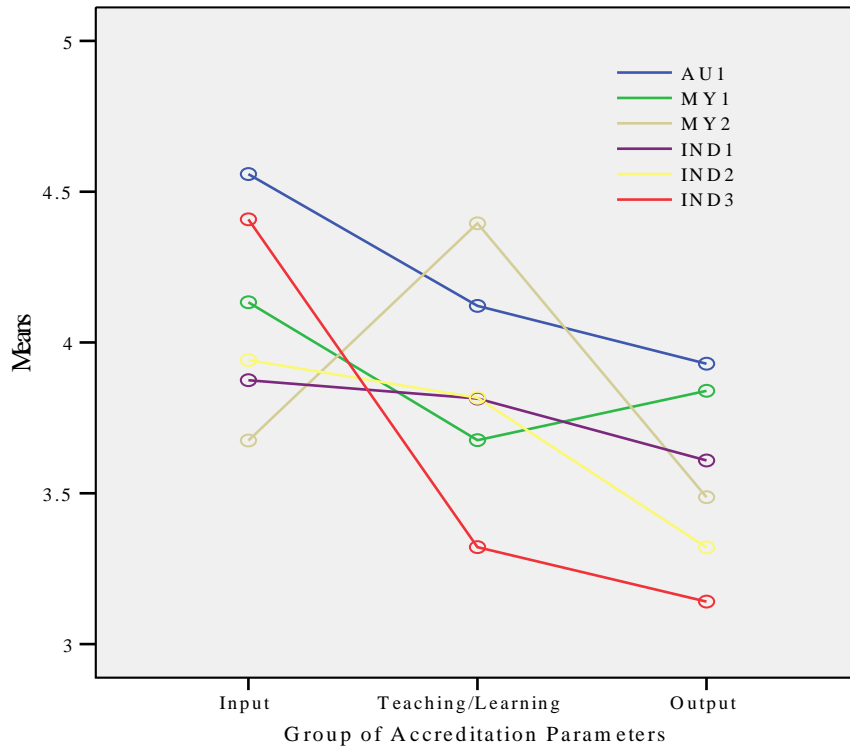


Figure 3: Graph of the means of sub-groups of accreditation parameters for three countries.

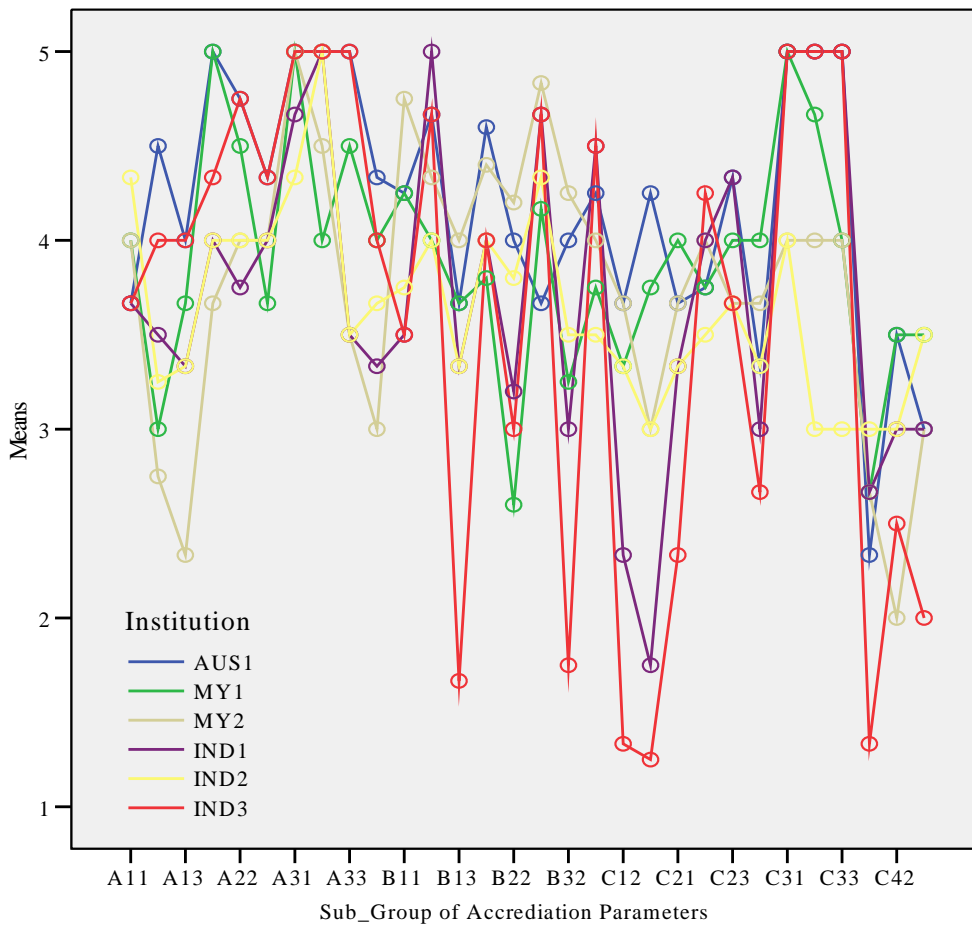


Figure 4: Graph showing accreditation performance for all six institutions.

Hypothesis 2: The accreditation criteria developed and applied in engineering education in Asia-Pacific countries neglects the educational process cycle as a whole.

If the Scheffe test is performed for multiple comparisons between the accreditation parameter groups, then the results are as outlined in Table 5. It has been found that there is a significant difference between the input and output ($p= 0.000$), as well as between the teaching-learning and output processes of the educational cycle ($p= 0.000$).

Table 5: Scheffe test for the multiple comparisons between the groups of educational process for the accreditation performances

(I) Group	(J) Group	Mean Difference (I-J)	Sig. (p)
Input	Teaching/Learning	.17	.081
	Output	.47(*)	.000
Teaching/Learning	Input	-.17	.081
	Output	.30(*)	.000
Output	Input	-.47(*)	.000
	Teaching/Learning	-.30(*)	.000

* The mean difference is significant at the .05 level.

Figure 5 shows a graph for the sub-group means of accreditation parameters (A11, A12,...B11, B12,..) plotted for the three countries. From the graph it is important to note the significant differences between the accreditation performances for three groups of accreditation criteria for the three countries. Interestingly, the output part/group shows significantly low score for all three countries.

In Figure 6 a graph for the Group means of accreditation parameters (Input, Teaching/Learning and Output) is plotted against all six institutions. The findings show the significant differences between the accreditation performances for all institutions. The three groups of accreditation criteria (input, teaching/learning and output) do not score at the same level and indicate significant differences in the score of accreditation parameters. Also, the output part/group of accreditation parameters has scored low compared to the other two parts, that is, input and teaching-learning.

Hypothesis 3: There is no clear-cut and comprehensive assessment of output part of the educational process cycle.

Various assessment models devised and implemented in higher education, including engineering education, have not revealed the qualitative assessment of the necessary graduate attributes. Furthermore, these models lack the clear-cut theoretical and conceptual base of the term generic attributes for graduates (Barrie, 2004). The fundamental process of incorporating graduate attributes into the course curricula is one factor whereas the proper assessment of these attributes is the second important issue. As a result, there is increasing debate and discussion about how to teach and assess graduate attributes? It is pertinent to develop generalised measures of knowledge and skill outcomes in higher education (Coates, 2007). The recent literature on the assessment of engineering programmes illustrates few examples of the developments of assessing professional skills, such as students' ability to evaluate and resolve ethical dilemmas, assessment of team skill development and project effectiveness, etc (Shuman, et al, 2005).

During the fieldwork and data collection, the authors found difficulties in obtaining data on graduate outcomes, including graduate employability. As a result, the data analysis shows low scores at the output part of the educational process cycle (Figures 3, 4, 5, 6) as well as significant difference between the input and output, and input and teaching learning process (Table 5). The reasons for this may be either graduate attributes (outcomes) are not clearly defined and monitored, or the assessment data for the graduate attributes and graduate outcomes is not well documented.

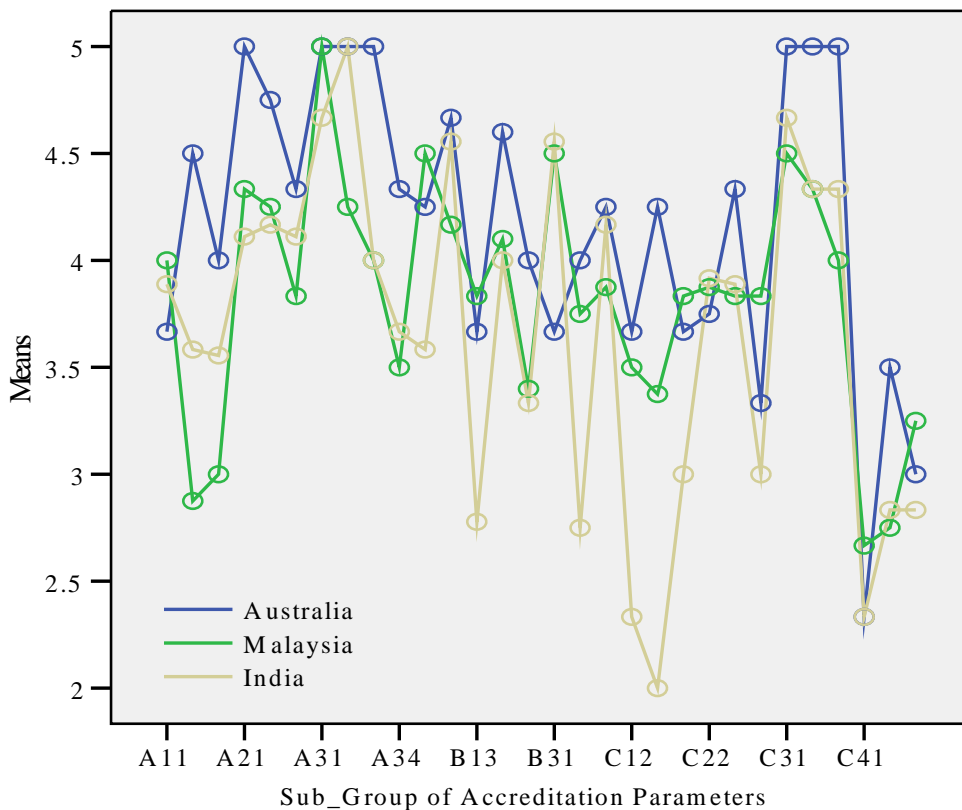


Figure 5: Graph of accreditation performance for three countries when plotted with sub-groups of accreditation parameters.

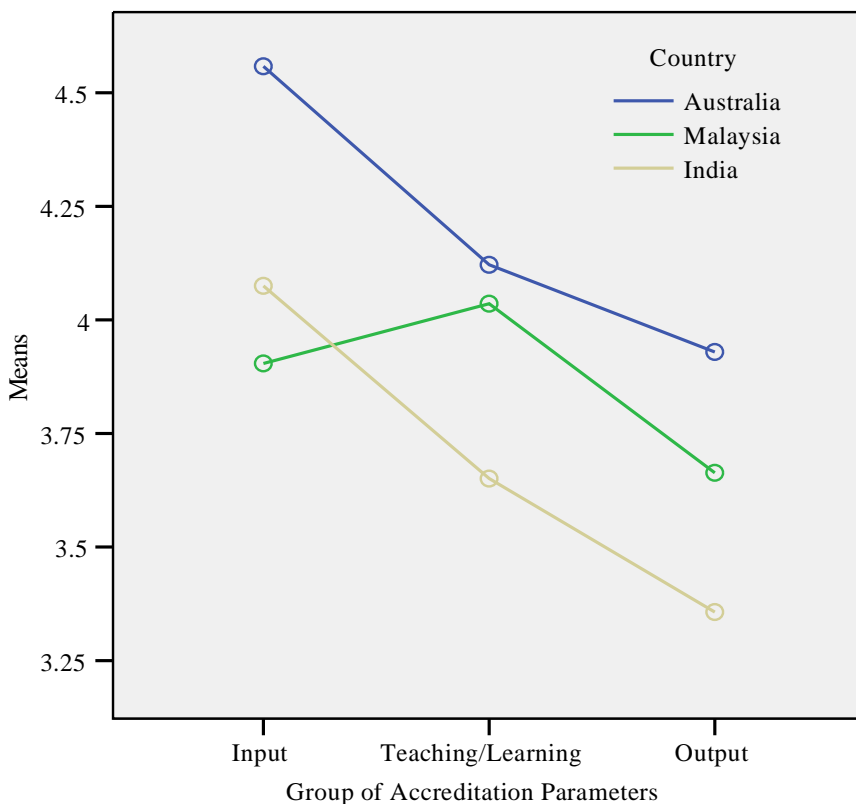


Figure 6: Graph showing accreditation performance for three countries when plotted with the groups of accreditation parameters.

Discussion

The data collected in the research project was from Australia, Malaysia and India, representing the Asia-Pacific region. The results presented and discussed in this paper strongly support the hypotheses made on engineering accreditation. It is also noted that during the fieldwork data collection it has been observed that greater progress and actions are required in documenting the required accreditation data. Furthermore, within the Asia-Pacific, the accreditation systems vary substantially and hence there is no uniformity. For example, in India, the accreditation process of engineering education is not fully developed whereas the accreditation cycle in Australia is well developed when compared to other Asia-Pacific nations. In most of the organisations within the Asia-Pacific, the graduate attributes are not clearly defined or well documented. Therefore, the output part of the accreditation criteria shows low performance scores compared to the other two parts, that is, input and teaching learning process. This is mainly due to uncertainty and difficulty in obtaining the performance data, such as, the assessment of graduate attributes or competencies, graduate employability, industry feedback, etc.

Care should be taken when comparing accreditation results from one country to another, and from one institution to another, as different people or institutions may evaluate the information in different ways. The best way to use the model may be to use it as a relative index to indicate where the weaknesses or potential problems in the accreditation cycle may be.

A single approach of a trans-national or global accreditation model is beneficial. The design and development of a global accreditation model must be clearly transparent and cover all necessary elements of educational process cycle as indicated in Figure 2. There are several benefits of the global model to engineering education and this model can be used as a universal and uniform accreditation tool to improve or strengthen the existing accreditation systems around the globe. This approach will facilitate global mobility of engineering professionals and also foster the mutual recognition of engineering education at all levels.

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