Industrial Engineering and the Application of Value Engineering in CARICOM Countries

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Abstract The World Book Encyclopedia defines Industrial engineering as being concerned with planning techniques of working, and the uses of machines in industry. It is the branch of engineering that concerns the development, improvement and evaluation of integrated systems of people, knowledge, information, equipment, energy, material and processes and draws upon the principles and methods of engineering analysis and design, to specify, predict and evaluate the results to be obtained from such systems. Industrial engineers are specialists in the field and work to eliminate wastes of time, money, materials, energy and other resources. The tools and techniques employed by industrial engineers can be utilised by entrepreneurs and organisations to create sustainable business enterprises in Caricom countries while adhering to international standards. Value engineering techniques may also be applied to build competitive advantages within the region and in the international market place. The effects of Value engineering (VE) on industrial engineering will impact projects throughout the Caribbean. VE is a methodology that is known and accepted in the industrial sector. It is an organised process with a history of improving value and quality. The VE process identifies opportunities to remove unnecessary costs, while assuring that quality, reliability, performance and other critical factors meet or exceed customer’s expectations.

Keywords: Industrial engineering, Industrial engineers, Value engineering

1. Introduction
This paper seeks to examine the impact of industrial engineering on manufacturing industries within the Caribbean region. As the Industrial Revolution continues throughout Caribbean Community (CARICOM) countries, many projects will be undertaken, particularly in Trinidad and Tobago, where mega projects such as the ‘Water Front Project’ in Port of Spain, are under construction. These projects and the establishment of Caribbean Single Market and Economy (CSME) promise opportunities for industrial engineers, as well as the development of industrial engineering and value engineering practices in the region’s industrialisation thrust.

Industrialisation is defined as the development of large industries in a country or economic system. Industrial engineering was developed out of the process of industrialisation and incorporates disciplines such as, Production and Operations Management, Management Science, Project Management, Marketing Management and Value Analysis/Engineering/Management. These disciplines are applied to industries and organisations throughout CARICOM countries in their quest to produce and market high quality products and services for regional and international consumption. The methodologies utilised in industrial engineering to develop and grow businesses, are similarly employed by contractors, entrepreneurs and individuals who seek to create value in their respective industries.

Industrialisation in CARICOM countries took place as Caribbean governments sought to undertake economic development in the various islands. The central concern of postwar economic theory and policy in the Caribbean was how to get the economy to grow fast enough. It was anticipated that rapid growth would place the territories in a position to close the gap in real income per head between the region and the metropolitan countries of the North Atlantic; to create sufficient employment to absorb population increase and enough social and economic equality to ensure political stability.

It was expected that the regional economy would ultimately be better placed to reduce, if not eliminate
its traditional dependence on metropolitan areas for investment, technology, skills and business enterprise, hence the development of industrial engineering in the region and the requirement for management skills in an industrial Caribbean environment, in order to ensure that the countries remain on the path to long term sustainable growth and development.

2. Caribbean Industrialisation
The distinguished St. Lucian economist and Nobel Prize winner, Professor William Arthur Lewis (1950) contended that agriculture did not have the capacity to provide employment for the masses. While the population of the Caribbean islands continued to grow, the small size of the Caribbean land mass limited expansion of the agricultural sector. He stated further that continued absorption of surplus labour into the agricultural sector had the effect of reducing productivity levels on the plantations. Put differently, there was over-employment on the estates to the extent that the absence of a few workers would have had little or no effect on productivity levels.

Industry would draw the surplus labour away from the ‘plantation’ into the ‘modern industrial sector’ leading to a rise in average productivity in the agricultural sector as well as an increase in wages above subsistence levels for workers in that sector (Lewis, 1950). At the same time, entrepreneurs in the modern industrial sector would offer higher than subsistence wages to lure workers out of the traditional agricultural sector. This increased wage level would be possible because of the expected higher productivity of workers in this sector following the absorption of the surplus labour away from agriculture. It was also anticipated that these entrepreneurs would continue to reinvest their profits into the expansion of their businesses, as well as to seek new entrepreneurial activities.

In the post war era, sentiments were expressed in the region in favour of industrialisation. It was argued that the quality of life for most citizens who had known nothing else apart from agriculture had deteriorated sharply because of the low productivity levels on farms. Also, agriculture was very limited in its ability to absorb the growing population due to the small land mass. According to Lewis (1950), it was recommended industrialisation as a means of complementing agriculture.

2.1. Three Models of Industrialisation
Industrialisation in Caribbean countries especially during the decade of the 1960s was informed by one or a combination of theories that were gaining prominence during that period. Three models of industrialisation were seen as providing the key to the transformation of the plantation economies of the region. These were as follows:

The first one was the Foreign Direct Investment model. Lewis (1950) suggested that attempts should be made to lure foreign firms into setting up operations in the Caribbean islands, so that they could bring with them the necessary entrepreneurial skills, capital, technology and market links. This became the popular development strategy in the 1960s, especially in Jamaica, Trinidad and Tobago and Barbados.

The second one was the Import Substitution Investment model. Under this model, a country may attempt to conserve scarce foreign exchange by substituting goods previously imported with locally produced products, often in a protected atmosphere. In the context of Caribbean societies in the decade of the 1960s, this involved the use of trade barriers to discourage imports and the setting up of infant industries to undertake production of the substitute. Trade barriers included the use of discriminatory devices such as tariffs, quotas, negative lists and licencing, as well as overvalued exchange rates. The protected industry was expected to mature over time to the point where it could compete on an equal basis with its foreign competitors.

The third one was The Resource-Based Industrialisation. In this mode of investment, territories would seek to exploit the comparative advantage they possess in a particular resource by investing in products closely tied to the resource. In this way it was hoped that backward and/or forward linkages would be based on the abundance of the natural resource the territories already possess. An example of resource based industrialisation is the Pt. Lisas Industrial Estate in Trinidad and Tobago, which was established in 1980. The Estate houses a number of petrochemical companies and other downstream industries such as iron and steel smelting, and methonal production all of which were set up to utilise the cheap and abundant supply of natural gas with which Trinidad and Tobago is endowed.

2.2 Industrialisation by Invitation – The Second Industrialisation Thrust (1958-1974)
The third world in general possessed “unlimited supplies of labour from the traditional sector”. Lewis (1950) suggested that a marriage of
convenience between this cheap and plentiful labour, and the capital and technology of the developed world could produce the missing engine of growth and development in third world economies. This new economic strategy was later to be known as “Industrialisation by Invitation”.

2.2.1 The Period of Early Industrialisation
The Caribbean islands emerged from the nineteenth century primarily as agricultural economies in which sugar cane was the principal cash crop. This was to dictate several aspects of early industrialisation. In several of the islands steam-driven trains were used as transport for cane, and in the larger islands they were used as well for cargo and passenger transport. Heavy manpower resources were necessary to operate and maintain the engines, carriages and rails. Much of the early introduction to machinery was in connection with the steam engine as the prime motive. The processing or refining of the cane to produce sugar, itself created a well-equipped army of expert technicians and skilled tradesmen. This was the background of the early industrialisation in the West Indies up to the pre-World War II period.

2.2.2 Establishment of the Caribbean Community (CARICOM)
CARICOM was established in 1973 on the basis of a treaty. The original signatories to the Treaty were Prime Ministers Errol Barrow for Barbados, Forbes Burnham for Guyana, Michael Manley for Jamaica and Eric Williams for Trinidad and Tobago. The objectives of the Community were set out in Article 4 of the Treaty and were based on (i) economic integration through a common market and common trade policies; (ii) functional cooperation (pooling of resources and sharing of services in the area of human and social development; and (iii) coordination of foreign policies, presenting a united front in its relations with countries outside the grouping.

2.2.3 Establishment of the Caribbean Single Market and Economy (CSME)
The decision by Caricom in 1989 to establish the Caricom Single Market and Economy (CSME) was intended to deepen the integration movement among the region and to better respond to the challenges of globalisation. CSME involves trade liberalisation in goods and services among members. It provides for the free movement of capital, skilled labour and the freedom to establish business enterprise anywhere in the Community.

The aim of CSME is to provide the opportunity for greater cooperation among businesses, to improve and increase the quality and quantity of goods and services they produce, and to do so at better prices. This regional market promises to be an effective platform upon which workers in the construction sector could market their profession. CSME, therefore, presents opportunities for improvement of skills, economic status and standard of living for members of Caricom countries. Table 1 depicts the development of CARICOM and CSME.

With the emergency of CSME, many projects would be undertaken throughout the region and many of these projects would be funded by international agencies. In this context, Caricom countries would be required to operate within the global village and participate in international trade in order for the region to benefit from greater economic opportunities. Project management proposes a feasible approach to manage projects in industries and ensure that CSME remains viable. The management of projects would play an important role throughout the Caribbean region to ensure that projects are completed on time and within budget. According to the Project Management Body of Knowledge, Project Management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements.

3. Industrialisation and Industrial Engineering in CARICOM Countries
Industrialisation continues unabated throughout Caricom countries and many manual activities have been replaced by engineering capabilities, to eliminate waste on production lines, and increase production of goods and services. Industrial engineering utilises time and motion to increase productivity in the workplace. It examines work systems and maximises efficiency to produce products safely. For example, computerised industrial engineering machines are used to produce various types of items for industrial use; computerised robotic machines are used to drill holes and insert screws and bolts in large equipment for industrial use in various sectors of the economy. These processes contribute to efficiency in factories and manufacturing industries, as they lower the unit cost of production and enable firms to attract more customers.
Table 1. The Development of CARICOM and CSME

<table>
<thead>
<tr>
<th>Period of Existence</th>
<th>Name</th>
<th>Agreement/ Treaty</th>
<th>Main Objective</th>
<th>Signatories</th>
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<tbody>
<tr>
<td>1973</td>
<td>Caribbean Community and Common Market (CARICOM)</td>
<td>Dickenson Bay Agreement</td>
<td>Economic integration, foreign policy coordination and functional cooperation</td>
<td>Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts-Nevis, St. Lucia, St. Vincent and the Grenadines, Surinam and Trinidad and Tobago. Associated members are Anguilla, Bermuda, British Virgin Islands, the Cayman Island and Turks and Caicos Islands.</td>
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<tr>
<td>1981</td>
<td>Organisation of Eastern Caribbean States (OECS)</td>
<td>Treaty of Chaguaramas</td>
<td>Economic integration and cooperation in a range or areas such as external relations; human and social development; and defence</td>
<td>Antigua and Barbuda, Dominica, Grenada, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines. Associate members are Anguilla and the British Virgin Islands</td>
</tr>
<tr>
<td>2001</td>
<td>Caribbean Community including the Single Market and Economy (CSME)</td>
<td>Treaty of Basseterre</td>
<td>Further intensified economic integration, through a Single Market and Economy, foreign policy coordination and functional cooperation.</td>
<td>All member states except The Bahamas and Montserrat.</td>
</tr>
</tbody>
</table>

Throughout the Caribbean industrial estates are developed to increase production processes. In Trinidad and Tobago, some of these estates are (i) Philideco, in Pt. Lisas, Couva; (ii) O’Meara Industrial Estate in Arima; (iii) Diego Martin Industrial Estate in Diego Martin; and (iv) Trincity Industrial Estate in Trincity, where highly industrial processes are carried out in order to increase the production of quality goods.

The Government of Trinidad and Tobago also utilises industrial engineering techniques in its housing projects to build pre-fabricated houses at its La Horquetta, Maloney and Malabar Housing Development Projects. In this way, buildings are constructed at a faster rate and are generally more cost effective. Private contractors also use pre-fabricated concrete slabs to build houses at Santa Rose Heights in Arima, Trinidad.

Pre-fabricated concrete walls are mass produced, by industrial engineering techniques in factories such as Spancrete Limited, which is situated at the O’Meara Industrial Estate in Arima, Trinidad. Spancrete uses industrial engineering electronic equipment to mass produce concrete walls and roofs and other concrete structures for the construction sector. The company specialises in pre-fabricated building systems for the construction sector, and exports its building systems throughout the Caribbean. Environmental-friendly materials are used in the building system, which can withstand cyclonic winds, earthquakes, tremors, extreme climatic conditions, rotting and fire. The pre-fabricated building system is precision-engineered and cause components to lock easily and smoothly.

Another company contributing to the development of the industrial environment in Trinidad and Tobago, is the Caribbean Steel Mills Limited, where steel and steel products are produced for local, regional and international purposes, utilising industrial engineering methodologies. Caribbean Steel Mills Limited, pioneers in the steel industry in Trinidad and Tobago, is one of the most diversified manufacturing enterprises in the Caribbean. Its founder, Percival Bain, in 1970 recognised that there was a need in the industrial thrust for steel and steel-related products. The company began operations in 1972 with a Tube Mill equipped with Italian-made machinery for the production of structural, furniture and automotive tubing.

In the 1980s, the facilities of this mill were expanded to utilise radio frequency welding...
technology for increased efficiency. A Profile Mill was installed, thereby widening the product range to include roofing sheets; factory cladding; ridging; purlins; composite floor decking door and window profiles. A mini Re-rolling Bar Mill which was installed in 1974 for the manufacturing of rounds, rebars and squares for the construction industry, was re-commissioned in 1992 to meet the expanding needs of the industry, locally and abroad. As a result of this restructuring, Caribbean Steel Mills was able to service the building, furniture and automotive industries. Recognising the need to maintain consistent product quality and in keeping with its export thrust, Caribbean Steel Mills re-engineered its activities, adopted a quality management system and obtained ISO certification in 1997.

Emanating from the industrialisation thrust in Caricom countries, professional bodies were established to provide oversight for the various industries operating in the Caribbean. One such organisation is the Trinidad and Tobago Manufacturing Association (TTMA). As Caribbean countries embark upon developmental projects to expand their economies, many projects will be undertaken. In executing these projects, various types of contracts will also be utilised for the procurement of goods and services. As a consequence, management skills must be applied by engineers and project managers, who are involved in the tendering and procurement processes of public and private contracts in CARICOM countries.

4. Contracts Utilised in Industries
Several different types of contracts are employed in the construction sector in CARICOM countries. The different types of contracts tell how the parties involved intend to measure the work done and consequently how payments are to be made. The central question facing senior managers and professionals in dealing with contracts revolves around the selection of a particular type of contract in a given situation. Three types of contracts commonly used in CARICOM countries are as follows:

Admeasurement Contracts - An admeasurement contract is one in which all payments associated with measurement of work during the execution of the contract must be treated as interim payments and all the measurements as approximate measurements. A final measurement is to be carried out at the end of the works or at clearly identified and previously specified points in the execution of the works.

Lumps Sum Contracts - A lump sum contract is one in which a tender or bid is for a sum specified, with no reference made to the items of work. An agreement can be entered into by which payment can be made in tranches based on agreed milestones for completed work.

Cost Plus Contracts - A Cost plus contract, also called reimbursement contract, may appear in several forms. The cost of the works (e.g., materials, machinery and equipment, labour and services) must be computed by adding up the various bills which represent payment by the contractor.

The acquisition of contracts in CARICOM countries will demand ethical behaviour on the part of engineers, consultants, contractors and other stakeholders, which will require ethical codes. Codes of practice, like specifications and technical standards are guidelines of good practice based on scientific principles and the accumulation of wisdom drawn from wide experience. Suite (2001) states that codes of practice seek to govern the technical discharge of professional duties and how professionals carry out the works or the tasks at hand. A Code of Ethics seeks to govern the conduct or how people relate to other human beings with which they interact.

Professional organizations, such as the Association of Professional Engineers and the Architect Association, which are governed by Codes or Ethics are expected to play a pivotal role in the training of professionals in industrial engineering. These associations are self-regulating and set standards to govern the conduct of their members, as well as protect the public from unethical conduct of their members. Membership in these learned societies will provide a platform for professionals in industrial engineering to carry out their functions in a professional and ethical manner when dealing with other professionals, and the public in general. To this end, the procurement process in CARICOM countries demands scrutiny.

5. Public Procurement
Procurement has become an important and essential factor in the various industries in Caricom countries in the pursuit of industrial engineering and value engineering activities. Procurement is the acquisition of goods, works or services. Good procurement practices involve the selection of goods, works or services from a single or multiple sources to increase profitability and minimise cash flow problems by seeking out quality suppliers.

Public procurement is the process of acquiring property and services for public purposes. It involves
the utilisation of public money in a complexity of processes and choices in which - (i) needs are evaluated; (ii) products and services are identified; (iii) forms of delivery and methodology are identified; (iv) contractual arrangements to be entered into, and (v) works or services are performed.

Engineers, contractors and other stakeholders in industrial engineering could market their profession by bidding for contracts, using contract procurement systems, which have been developed overtime, from the Traditional Procurement Systems to the Build, Operate, Own, Transfer (BOOT) System. (Suite 1993) In so doing, these professionals can partner with their counterparts in CARICOM countries in the acquisition of contracts which should reflect uniformity in procurement processes, conformity to agreed principles and be consistent with best practices.

As professionals in industrial engineering seek to expand their careers regionally, knowledge of the various contract procurement systems will enhance their performance and add value to their profession. However, the success of any procurement system depends on a clear articulation and understanding of what the legal and regulatory framework seeks to achieve. The framework must reflect the required objectives. In the context of CARICOM countries, these objectives should include (i) greater public accountability; (ii) promotion of greater transparency in public procurement; (iii) consistency with and support of government policies; (iv) effective and efficient contract performance; and (v) value for money.

6. Value Methods in Managing Projects
Value resides in any sort of interest or appreciation of an object, event or state of affairs. Such appreciation involves feeling and ultimately desires tendencies or needs underlying the feeling (Pun, 2007). Customers will be satisfied if products and services provide them with value, consequently, organisations should create and maintain superior business performance, to improve their processes, products and services and so ensure a high rate of success. Value must reside in all industrial engineering processes and value engineering will ensure that the processes are undertaken efficiently.

Stakeholders expect value in return for their investments therefore, value analysis (VA); value engineering (VE) and value management (VM) become necessary in an industrial environment. Value Analysis is an orderly and creative method to increase the value of an item. This item can be a product, a system, a process, a procedure, a plan, a machine, equipment, tool, a service or a method of working.

6.1 Value Analysis
Value analysis identifies both the economic cost and use the performance value of the facility based on an initial project cost and total life cycle costs, as well as taking into consideration the safety and maintainability factors. Emphasis is also given to the social values based on the acceptability and adaptability to changing needs for the benefit of the society and human welfare. The value of an item is how well the item does its function by the cost of the item, i.e.: Value of an item = performance of its function/cost.

VA provides project managers with a powerful tool for maintaining quality standards while eliminating unnecessary costs and giving visibility for cost reduction efforts in the event of cost growth. Cost growth is one of the most difficult items to correct in industrial engineering. VA provides a “how to” answer to the question – “What can be done to reduce costs, yet maintain technical performance?” In addition to completing a project with technical excellence, and on time, the project must be completed within budget to be fully successful.

The VA methodology is most useful in the cost control aspect of industrial engineering activities, since it maintains quality while eliminating unnecessary costs, once it is used up-front in the conceptual stage. VA is used in the product planning, design, and support phases and its methodology provides insight into relationships of functions.

Value Analysis has been successfully used in all engineering disciplines and specialties and in organisations with the human and social services fields. The process is a structured sequential plan or strategy (Dell’Isola, 1997; Kelly et al., 2003). It consists of four (4) phases:

1) The Information Phase - The emphasis in this phase is on the creative thinking activities, that is, idea generation and evaluation of creative ideas. Therefore four tasks in the information phase include (i) Data Collection; (ii) Function identification; (iii) Cost analysis, and (iv) User reaction surveys.

2) The Speculation Phase - In this phase brainstorming takes place to answer questions such as (i) what else could do the job? (ii) in what other ways can each function be performed? All ideas are
recorded and shared.

3) **The Evaluation and Analysis Phase** - The brainstormed ideas are evaluated in terms of cost, feasibility and other relevant criteria. The key objective for this phase is to improve ideas. This phase is very important for those functions that have a high acceptance or a high cost.

4) **The Implementation Phase** - The objective of this phase is to sell the recommended improvements to stakeholders for the product resulting from the Value Analysis study. A proposal is prepared that demonstrates that the proposed changes are technically feasible and meet the management objectives. Substantial cost savings are also documented. Schedules and budgets for implementation need to be prepared as well as an assessment of the new skill and employee training that will be required.

### 6.2 Value Engineering

Value Engineering is a methodology that is known and accepted in the industrial sector. It is an organised process which improves value and quality. The VE process identifies opportunities to remove unnecessary costs while assuring that quality, reliability, performance, and other critical factors will meet or exceed the customer’s expectations in the industrial engineering environment.

The VE process embodies the function analysis discipline within a structured problem-solving methodology. Function analysis is the core of VE and is the basic discipline that provides the power that makes the methodology work.

A relationship between functions is obtained through use of a function analysis system technique (FAST) diagram. The diagram provides graphic two-dimensional presentation of the functions and identifies the basic function, secondary and supporting functions, higher-order functions and various other variations. It also assists in defining a critical path of functions starting from the initiating element through the supporting functions and basic function, to the higher-order function.

The FAST diagram does not provide the solution, but it defines the problems and shows the cost imbalances so that analysts can search for alternative solutions, which can reduce the costs of secondary functions or eliminate unnecessary functions and the costs associated with them.

### 6.3 Value Management

Value management is a process in which functional benefits of a project are made explicit and appraised consistent with a value system determined by the client. The client for the project will implicitly or explicitly establish a value system for the project. The definition of value is a relationship between time, cost and the variables that determine the quality the client seeks from the finished project. The main purpose of the value management is to make sure that a client receives the best value for money, ensuring higher *quality* and *performance* based on up-to-date technology for least cost.

Customers will be satisfied if products and services provide them with value. The effectiveness of value management relies upon the ability of managers to create a strategy that develops an organisation system consisting of (i) training, (ii) jobs, (iii) relationships, (iv) measurements, and (v) information systems that enable effective use of process management, which, when implemented enhances customer success through a supportive organisation culture and a focus on continuous improvement. The VM concept is useful for providing ever-improving value to customers and the improvement of overall company performance and capability.

The method of value management includes:

1) **Development of Organisational Mission and Strategy** – To communicate the organisation’s mission and strategy to all individuals in the organisation.

2) **Training** – For increased efficiency, quality, productivity and job satisfaction.

3) **Job Design** – To develop processes and people into a coherent system and transition to the flatter, more responsive form of management.

4) **Interface Relations** – To involve the customer in internal operations and to develop a ‘customer focus.’

5) **Performance Measurement System** – Performance metrics to – (i) support the attainment of the company’s objectives; (ii) link an individual’s decisions to the firm’s strategy; and (iii) track both the performance of the processes and the quality of the interactions.

6) **Information Systems** – To ensure that individuals and teams receive accurate information in a timely manner, because prompt, consistent provision of customer and performance data is necessary to enable effective response within the chain.

7) **Process Management** – Methodological and personnel practices that are used to manage processes throughout the value chain.

8) **Organisation Culture** – Culture is that set of values, beliefs and understanding that are shared by
the members of the organisation.

9) Continuous Improvement - An organisation’s efforts to continually strengthen the organisational culture and improve the performance of the supply chain will lead to greater customer success.

10) Customer Success – Meeting the needs of customers is a key to competitive success.

7. Industrial Engineering and Value Method

Industrial engineering (IE) is the branch of engineering that concerns the development, improvement and evaluation of integrated systems of people, knowledge, information, equipment, energy, material and processes and draws upon the principles and methods of engineering analysis and design, to specify, predict and evaluate the results to be obtained from such systems. Industrial engineers are specialists in the field and work to eliminate wastes of time, money, materials, energy and other resources. The name ‘industrial engineer’ has originally been associated with manufacturing but it has grown to encompass services and other industries which include Management Science, Operations Management, Project Management and Value Engineering (Heizer and Render, 2001).

The same tools and techniques employed by industrial engineers can be utilised by entrepreneurs and organisations to create sustainable business enterprises in Caricom countries while adhering to international standards. Management must: develop clear goals, systems, and motivation.

2) Continuous training can enhance the performance of individuals by enabling them to make better decisions, work as a team, and adapt to change, while also increasing efficiency, quality, productivity and job satisfaction.

3) Jobs may need to be redesigned to include a whole or more complete task as well as adequate authority and responsibility.

4) Involvement of the suppliers in the organisation’s operations is equally essential in value management.

5) Performance objectives and metrics provide focus for an individual or team’s effort, but performance feedback is needed to enable individuals to improve performance, processes and interactions.

6) Select customers and providers who are using electronic data interchange (EDI) and the internet to transfer order requirements, order status information, invoices and quality requirements between firms. These systems have reduced material and labour costs, increased the accuracy and speed of operations, as well as improved relations between firms.

7) The use of process management works both to strengthen the organisation culture and enhance continuous improvement in the supply chain.

8) Companies are increasingly relying upon the use of teams and are discovering numerous benefits, including the often-unrecognised benefit of the development of a supportive organisation culture.

9) Improvements can occur incrementally or through the use of “breakthroughs” or innovations, but for either to occur, the employees must be trained in the use of improvement techniques as well as in topics like problem solving, interpersonal skills, basic business and technical skills, team building and customer value.

8. Conclusion

The Industrial Revolution has impacted CARICOM countries to the extent that industrial engineering co-exists alongside other functional areas in industries throughout the region. Engineered building systems, such as pre-fabricated concrete walls and light-weight galvanized steel, adapt to Caricom countries varied and demanding climatic conditions.
Table 2. A structured framework for incorporating IE with VA/VE/VM practices

<table>
<thead>
<tr>
<th>Major Phases</th>
<th>Stages</th>
<th>Activities</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation and diagnostic</td>
<td>Orientation and diagnostic</td>
<td>Hold briefing meeting with commissioning project sponsor.</td>
<td>The orientation and diagnostic phase is concerned with understanding the strategic context of the value study, its scope, timing, schedule and constraints.</td>
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<tr>
<td>Phase</td>
<td>phase</td>
<td>Define objectives of value study in relation to organisation’s VM policy.</td>
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<td></td>
<td>Identify and gain commitment from stakeholders.</td>
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<td></td>
<td></td>
<td>Agree on implementation with project sponsor.</td>
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<tr>
<td></td>
<td>Orientation and diagnostic</td>
<td>Define VM study Scope</td>
<td>The exact nature of the study style will be determined and needs to be agreed with the project sponsor. This will determine the deliverables and the performance criteria for a successful study.</td>
</tr>
<tr>
<td></td>
<td>phase</td>
<td>Determine study style</td>
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<td></td>
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<td>Agree scope and objectives of study with decision</td>
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<td>maker/project sponsor.</td>
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<td>Agree constraints for VM study – real and apparent.</td>
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<td>Determine the time scale for the VM study.</td>
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<td></td>
<td>Gather comprehensive data</td>
<td>Interview VM study participants.</td>
<td>It is important that the value manager gathers all relevant information. This may include revisiting stakeholders and interviewing other potential participants if a team of records is to be used. If an independent VM study team is to be assembled it is important that skills are tailored to the problem at hand.</td>
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<td></td>
<td>for the VM study</td>
<td>Collect user/customer attitudes</td>
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<td></td>
<td></td>
<td>Build data models</td>
<td></td>
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<tr>
<td></td>
<td>Identify and select team</td>
<td>Finalise VM team composition and agree with project sponsor</td>
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<td></td>
<td>Study logistics</td>
<td>Brief participants with a meeting or with prepared documentation.</td>
<td>Briefing the VM study team is also important during this phase. This could be undertaken during confidential interviews, through a presentation.</td>
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<tr>
<td></td>
<td></td>
<td>Arrange venue</td>
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<td></td>
<td>Develop workshop agenda and</td>
<td>Agree workshop phase agenda with project sponsor.</td>
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<td></td>
<td>process</td>
<td>Identify tools and techniques for use during workshop.</td>
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<tr>
<td>Workshop Phase</td>
<td>Information sharing</td>
<td>Confirm value study objectives with VM team.</td>
<td>During this part of the workshop phase, the agenda and participants to the workshop will be introduced.</td>
</tr>
<tr>
<td></td>
<td>Back-to-basics; function</td>
<td>Identify and classify functions</td>
<td>This is an important part of the workshop phase. It is central to value management and cannot be rushed. The experience of the authors is that it should not be omitted. Functional analysis diagrams will be constructed and other forms of analysis may also be used at this stage.</td>
</tr>
<tr>
<td></td>
<td>analysis</td>
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<tr>
<td></td>
<td>Create solutions and generate</td>
<td>Gather existing ideas.</td>
<td>Creating new ideas or options is almost always undertaken by brainstorming.</td>
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<tr>
<td></td>
<td>innovation</td>
<td>Create new ideas and options</td>
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<tr>
<td></td>
<td>Evaluate possible solutions</td>
<td>Evaluate solutions in terms of:</td>
<td>It is also at this point that working groups are likely to be formed as part of the workshop phase, if they have not been operating in an earlier section.</td>
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<td></td>
<td></td>
<td>- Client acceptability</td>
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<td></td>
<td></td>
<td>- Functional suitability</td>
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<td></td>
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<td>- Economic feasibility</td>
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<td></td>
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<td>- Technical feasibility</td>
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<tr>
<td>Present and validate proposals</td>
<td>Work group presentations during final plenary. Presentation to senior management, if attending</td>
<td>Working groups can present to each other in a plenary session to cross-validate ideas/options for final agreement. Often a presentation to executives can be a good focusing mechanism at the end of a workshop to provide further broader inputs into team thinking.</td>
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<tr>
<td>Action planning for implementation</td>
<td>Develop implementation programme:  - List activities to be carried out;  - Identify time frames;  - Appoint action plan coordinator;  - Identify follow-up meeting/workshop one month after workshop complete.</td>
<td>The development of an action plan commences the process of implementation. Follow-up meetings can also be targeted, especially for presentation of the workshop report to the project sponsor/senior executives.</td>
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<tr>
<td>Prepare report</td>
<td>Prepare and issue draft report</td>
<td>This aspect can be helped if a recorder is employed to note the workshop proceedings</td>
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<tr>
<td>Present report and agree on final implementation</td>
<td>Present draft and oral report to project sponsor. Inform VM team of outcomes, dismiss or place on standby. Prepare and issue final report.</td>
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</tbody>
</table>

**IMPLEMENTATION PHASE**

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Disseminate report</th>
<th>Disseminate report to:  - Client project sponsor;  - VM team  - Other experts involved in VM study</th>
<th>Experience suggests that the post workshop phase needs further refinement to ensure that implementation of ideas/solutions continues. This could also include further, more detailed working up of options once the workshop has been completed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support implementation</td>
<td>Monitor status of actions; follow-up implementation and assist to correct deviations Obtain commitment implementation programme</td>
<td>Implementation workshop is very useful to continue the progress of implementation, or at a minimum a meeting with the project sponsor/senior executives to finalise the outcomes of a study. Often this is integrated with the presentation of the draft report.</td>
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<tr>
<td>Continuous improvement</td>
<td>Collate information on implementation targets and VM study performance Review strengths and weaknesses of VM study with project sponsor. Adjust VM study process and procedure.</td>
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</tbody>
</table>

Advantages of these systems include minimum components, easy assembly, easy shipment, maximum strength, and durability. These systems are used by industrial engineers who are important players in numerous fields of industrial development that meet and surpass stakeholders’ expectations by providing value in deliverables.

Industrial engineering has contributed greatly to industrialisation process in Caricom countries, utilising pre-fabricated concrete walls and steel on a
large scale for the construction sector and for export throughout the Caribbean, Latin and South America. These products provide stable foundations, simple connections, simple relocation, easy extension and environmental-friendly solutions to the construction sector. This, as well as other industries, has provided employment for skilled and semi-skilled labourers, engineers and other professionals throughout Caricom countries, in keeping with the goals and objectives of CSME.

The Government of Trinidad and Tobago, in its Vision 20/20 initiative, has embarked upon a number of construction projects, chief among them is the Waterfront Development Project in Port of Spain, where a number of buildings are being constructed. At these building sites, industrial engineering takes centre stage, demonstrating the use of large industrial equipments and machinery utilising pre-fabricated concrete walls and steel produced at industrial estates throughout the country. Industrial engineers then collaborate and utilise industrial engineering and value engineering techniques to transform the country’s capital to developed country status.

From the aforementioned, it could be concluded that VA/VE/VM in industrial engineering would benefit Caricom countries in their current and future development initiatives. The future holds a bright future in CARICOM countries: It is anticipated that organisations must employ a structured framework to guide them along a process management path which would result in a methodology for continuous improvement of processes, products and services in order to enhance customer success.

VM must be implemented within organisations process management, as this contributes to the strengthening of the organisation’s culture with emphasis on continuous improvement. Moreover, managers must ensure that individuals and teams receive accurate information in a timely manner because prompt, consistent provision of customer and performance data is necessary to enable effective response within the chain.

References

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Suite, W.H.E. (2001), Conflict of Interest and the Ethical Dilemma in Construction, University of the West Indies, Trinidad and Tobago

Biographical Notes:

Carmina Drayton worked for several years in the Public Service as a Secretary before opting for a career change. She is currently employed in the Private Sector as an Administrative Assistant with RBTT Bank Limited. Ms Drayton began her tertiary education at the same time her two children were pursuing their University education at the University of the West Indies (UWI), St Augustine and Cave Hill. She pursued her BSc degree in Management Studies at UWI, St. Augustine, and is currently pursuing her MSc in Project Management at the Faculty of Engineering, UWI, St. Augustine.