Industrial Engineering Education and Research: Current Issues and Future Directions for the Caribbean

Colin O. Benjamin1*, Leslie Monplaisir2, Clement K. Sankat3 and Denise Thompson4

1School of Business and Industry, Florida A&M University, 1500 Wahnish Way, Tallahassee, Florida 32307, USA; E-mail: colin.benjamin@famu.edu
2College of Engineering, Wayne State University, 4815 Fourth Street. Room 2163, Detroit, MI 48202, USA; E-mail: ad5365@wayne.edu
3Faculty of Engineering, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago E-mail: principal@sta.uwi.tt
4Centre for Innovation, Development, Enterprise & Strategy, University of Trinidad and Tobago, Arima, Trinidad, West Indies; E-mail: denise.thompson@utt.edu.tt

* - Corresponding Author

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Abstract: We discuss the challenges and opportunities presented to Industrial Engineering (IE) educators and researchers by contemporary issues related to the internet, globalisation, changing demographics, national security, lean and green manufacturing, and entrepreneurship. Case studies of ongoing initiatives in academia are provided as models to assist in charting future directions in IE Education and Research in the Caribbean by redefining programme focus, bridging the theory/practice gap, developing strategic alliances, and implementing campus-wide initiatives in Entrepreneurship. We propose the adoption of a Quality Function Deployment framework to assist IE programme stakeholders in the Caribbean - faculty, students, alumni and employers, in examining the local impact of these global issues on IE programmes and in conducting periodic review and re-examination of their mission to develop appropriate strategies and initiate programme enhancements. To be effective, IE education and training programmes in the Caribbean will require ongoing inter-university and industry-academia collaboration to ensure good resource utilisation and effective integration of teaching, research and service activities.

Keywords: Industrial Engineering, education, research, curriculum, stakeholder

1. Introduction

Industrial engineering is defined by the Institute of Industrial Engineers as being “concerned with the design, improvement, and installation of integrated systems of people, materials, information, equipment, and energy. It draws upon specialised knowledge and skills in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems” (www.iienet.org). Industrial engineers are mostly concerned with increasing productivity through the management of people, methods of business organisation, and technology. To solve organisational, production, and related problems efficiently, industrial engineers carefully study the product requirements, use mathematical methods to meet those requirements, and design manufacturing and information systems. They develop management control systems to aid in financial planning and cost analysis, and design production planning and control systems to coordinate activities and ensure product quality. They also design or improve systems for the physical distribution of goods and services, determine the most efficient plant locations, and also develop wage and salary administration systems and job evaluation programmes (www.bls.gov). In the Caribbean, IEs can apply these skill sets to make significant contributions to the region’s social and economic development by reducing waste and increasing
productivity in existing organisations and developing new, sustainable and profitable business ventures.

Since its inception as a small undergraduate programme in the early 80’s, the IE programme at the University of the West Indies (UWI) has been at the forefront of IE education and research in the Caribbean. Table 1 shows the geographical distribution of UWI IE graduates. Many have assumed leadership roles outside of the traditional engineering fields e.g. in business, banking and finance, and have made sterling contributions to the economic development of the Caribbean.

Over the years, Industrial Engineering Education and Research has moved from a focus on traditional IE techniques such as Work Measurement and Management Science to incorporate newer techniques developed to solve problems in exciting areas such as Computer Integrated Manufacturing, Lean and Green Manufacturing, Artificial Intelligence, Data Mining, Electronic Commerce, Human Computer Interaction, Information Technology, and Supply Chain Management. IE programmes in the Caribbean are needed to conduct a critical review and re-examination of their mission and develop appropriate strategies and programme enhancements to exploit current opportunities and respond to meet the important human resource development needs of stakeholders in government, business, industry and the community.

Table 1. IE Graduates of the University of the West Indies

<table>
<thead>
<tr>
<th>Territory</th>
<th>IE Graduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barbados</td>
<td>12</td>
</tr>
<tr>
<td>Belize</td>
<td>2</td>
</tr>
<tr>
<td>Dominica</td>
<td>2</td>
</tr>
<tr>
<td>Grenada</td>
<td>2</td>
</tr>
<tr>
<td>Guyana</td>
<td>2</td>
</tr>
<tr>
<td>Jamaica</td>
<td>84</td>
</tr>
<tr>
<td>Montserrat</td>
<td>1</td>
</tr>
<tr>
<td>St. Kitts &amp; Nevis</td>
<td>3</td>
</tr>
<tr>
<td>St. Lucia</td>
<td>2</td>
</tr>
<tr>
<td>St. Vincent</td>
<td>3</td>
</tr>
<tr>
<td>Trinidad &amp; Tobago</td>
<td>221</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>336</strong></td>
</tr>
</tbody>
</table>

This paper discusses the challenges and opportunities presented to IE educators and researchers in the Caribbean by contemporary issues related to the internet, globalisation, changing demographics, national security, lean and green manufacturing and entrepreneurship. We provide case studies of ongoing initiatives in academia to chart future directions in IE Education and Research by redefining programme focus, bridging the theory/practice gap, developing strategic alliances, and implementing campus-wide initiatives in Entrepreneurship. IE programme stakeholders in the Caribbean are encouraged to examine these global issues to expand the contributions of IE education and research to the region’s economic prosperity.

2. Current Issues in IE Education and Research

2.1 The Internet

The internet has revolutionised business practices and has fostered the development of new business models. Many companies today are focused on transforming themselves to be active participants in the digital economy where e-business is the norm (Turban et al., 2006). In the USA, major companies such as Schwab, IBM, Intel, and General Electric are rapidly moving towards a state where the Internet, intranets and extranets are integrated to conduct ECommerce activities (Slywotzky and Morrison, 2001; Weill and Vitale, 2001).

Although the literature identifies the several benefits of ECommerce (EC) to consumers, organisations and society, several limitations and barriers exist. One of the top 10 barriers to EC implementation identified in a 2000 study conducted by CommerceNet is the lack of qualified personnel. IE educational institutions can address this need by accelerating the use of the Internet to expand access to online training and education for consumers (www.Commerce.net). This is especially important for the islands of the Caribbean, which constitute the UWI System as a new communication technology, can bring courses based at the major campuses at Mona, Cave Hill and St. Augustine to a wider population of students on these Campuses but more importantly to the other islands of the region. Among the technological limitations identified (Turban et al., 2006) are:

- lack of universal standards for quality, security and reliability;
- still evolving software development tools; and
- difficulty in integrating Internet and EC software with some existing (especially legacy) applications and databases.

Also of interest to IEs are the non-technological limitations such as:

- the absence of mature measurement methodologies to quantify some of the benefits of Electronic Commerce;
• increasing online fraud; and
• difficulty in securing venture capital due to the failure of many dotcoms.

IE programmes in the Caribbean can readily select one or more of these areas for inquiry and develop relevant curriculum and related research programmes to address this current need. In some instances this may require collaboration with computer scientists and electrical engineers to tackle some of the technological limitations and the establishment of strategic alliances with the business community to develop solutions for the non-technological limitations.

2.2 Globalisation
Global business has become increasingly important to companies as foreign markets constitute an increasing portion of the Total World Market, foreign competitors increase their market shares in one another’s markets, and foreign markets emerge as essential sources of low-cost products, technology, and financial and human capital. Effective information management is of critical importance as companies seek to compete both in the physical marketplace and the virtual marketspace and depend on a reliable information resource (Terpstra, 2006). Industrial engineering can assist Caribbean organisations in the development of robust systems to support both tactical and strategic decision-making in the areas of global sourcing, global logistics, global servicing, global competition, strategic partnerships, global project management, and global supplier relationships.

2.3 Changing Demographics
In the United States, the changing demographics will have a significant influence on the direction of IE education and research. The engineering professorate is rapidly aging and the pipeline of likely replacements is not as full as required as fewer US citizens opt to pursue advanced degrees in Engineering and Science. New immigration rules in the aftermath of 9/11 may exacerbate this problem by discouraging foreign students studying for advanced degrees in IE in the USA. In addition, the great diversity in race, culture and religious beliefs in the USA will result in a different mix in the pool of student talent available to pursue careers in IE. To meet its industrial engineering needs, the USA will increasingly have to place less reliance on non-nationals and develop innovative ways to persuade US high school students to accept the challenge of a career in Industrial Engineering. The Caribbean region is faced with similar challenges. Industrial Engineering as a career needs to be vigorously promoted to high school students, as it is an Engineering discipline that appears not to be understood and valued by both prospective students and employers. Both UWI and UTT should encourage and support some of its best graduates to pursue Ph.D. Degrees in IE thus developing the engineering educators and researchers of the future. Effective mentoring and the support of the professional industrial engineering organisations such as the Caribbean Council of Engineering Organisations (CCEO) and the Institute of Industrial Engineers (IIE) can have a significant impact on a student’s career decision.

2.4 National Security
Since 9/11, national security has been accorded very high priority particularly in the USA and most of the developed countries. Coordinated efforts are in place to develop systems to facilitate the early identification of potential terrorist threats and the initiation of actions to neutralise them (Wise, 2007). Streamlined management systems are required to ensure smooth distribution of vital relief supplies to survivors of natural disasters such as Katrina and the recent devastating hurricanes in the Caribbean (e.g. Ivan). Significant disparities in economic opportunities in the Caribbean can promote the existence of a permanent underclass whose members may require assistance to break free from their economic shackles. Another threat is posed by the HIV/AIDS pandemic which presents policy makers with the ongoing challenge of making optimal allocation of the region’s resources. These areas will have a significant impact on the quality of life of all Caribbean residents and may well benefit from focused IE education and research activity.

2.5 Lean Systems and Green Manufacturing
Lean manufacturing is a team-based industrial philosophy that assists in identifying and eliminating waste by continuously improving product flow (Allen, 2001). Waste is any resource expended within a production system that does not change the fit, form, or function of a part and cannot add value to the manufacturing process. Introduced in post-war Japan, lean manufacturing has evolved into a customer specific process for developing sustainable and flexible business processes (Morgan and Liker, 2006). Critical to every lean production system is a flexible management organisation committed to addressing societal and environmental concerns.
which, in turn, impact the total image of the company (Brown, 1998).

Global competition and slow market growth force some organisations to make drastic changes in their operating strategies in order to compensate for poor productivity, traditional management practices that may prove to be barriers to implementation of any new major programme. Therefore, it can become necessary to restructure the management foundation (Eshbach, 2004) to alleviate the sometimes, chaotic environment that exists within an organisation when the progressions of change are not clearly defined. This restructuring of a plant or an entire company, when deemed appropriate, may enable an organisation to link management efforts to production improvements (Mascitelli, 2007).

Lean manufacturing seeks to produce and deliver the correct quality part or service to the right place, at the right cost, in the right quantity and in an environmentally conscious manner. This goal is especially important for small and medium-sized enterprises (SMEs) in the Caribbean region seeking to compete globally and sustain market growth. The challenges of IEs in lean systems design and manufacturing include the following:

- leveraging and optimising the use of global resources to create lean products for the global market place
- incorporating design reuse and standardisation principles in the design of global product platforms
- designing a lean supply chain to match manufacturing systems
- creating global teams to support lean organisations
- managing knowledge, quality, risk and change in the lean organisation
- designing and manufacturing products and services that are environmentally cognisant of the fragile island states in the region
- managing the life cycle of a product from idea generation through disposal

Of particular interest to industrial engineers in the Caribbean are the synergies to be obtained by combining the waste minimisation ideals of lean systems with environmentally friendly policies that encourage sustainable economic development. The Green Supplier Network developed in the USA (Murray, 2007) encourages large manufacturers to pursue the lean and clean advantage by conducting low-cost technical reviews for their suppliers to identify strategies for improving process lines and using materials more efficiently. Industrial engineers can spearhead efforts in the Caribbean to eliminate the root causes of waste and secure a stronger bottom line while improving environmental performance.

### 2.6 Entrepreneurship

Entrepreneurship education has been described as “the process of providing individuals with the ability to recognise commercial opportunities and the insight, self-esteem, knowledge and skills to act on them” (Jones and English, 2004). There has been growing interest in Entrepreneurship in academia with the concomitant development of new curricula, infrastructure, and research centers (Bowers et al., 2006). Kuratko (2005) suggests that entrepreneurship has emerged over the last two decades as the most potent economic force the world has ever experienced and recognises the remarkable expansion of entrepreneurship education and the ongoing struggle for academic legitimacy. Heinonen and Poikkijoki, (2006) explore the application of a range of teaching techniques to help university students inculcate entrepreneurial skills and behaviors. Hynes (1996) proposes a model to introduce entrepreneurship education into non-business disciplines while Jones and English (2004) describe a case study which adopts a process of student-centered learning in introducing a new entrepreneurship programme in Tasmania. Other researchers have examined the contribution of Entrepreneurship Centers (Bowers, 2006; Finkle et al., 2006).

Ropke (1998) believes that innovation in developed economies depends on the creation, application and diffusion of new knowledge through academic entities, more specifically, the university. In developing and emerging nations, institutions that use a proactive approach and adopt an entrepreneurial university model can have a positive impact on the socio-economic development of a region (Mian, 2006). In Trinidad and Tobago, for example, both the University of the West Indies (UWI) and the University of Trinidad and Tobago (UTT) have stated a commitment to entrepreneurship and innovation. UWI St. Augustine has identified innovation and entrepreneurship as one of its research pillars in its 2002-2007 strategic plan while UTT has implemented its Industrial Innovation, Entrepreneurship, and Management programme in order to create an environment where all entrepreneurial styles are encouraged and supported. IE may assist in promoting entrepreneurship throughout the Caribbean and create long-lasting partnerships among stakeholders in academia,
industry, and government thus paving a way for economic diversification and sustainable growth and development.

3. Future Directions in IE Education and Research

3.1 Determining Programme Focus

3.1.1 Overview

In determining the appropriate focus for IE programmes in the Caribbean, a Quality Function Deployment framework can be used to assist IE programme stakeholders (such as faculty, students, alumni and employers) in examining the local impact of global issues on IE programmes, designing a winning programme, and implementing programme enhancements. Quality Function Deployment (QFD) has been deployed to provide a structured approach for planning in academia in areas such as revising mechanical engineering curriculum (Ermer, 1995), research planning (Chen and Bullington, 1993), course design (Burgar, 1994), planning enhancements to computer laboratories (Benjamin et al., 1997), improving the quality of teaching (Lam and Zhao, 1998), and reviewing academic programmes (Pitman, 1995). QFD has also been widely used for curriculum planning in international educational environments. In the United Kingdom, QFD was utilised to build a degree programme in the Department of Vision Sciences at Aston University (Clayton, 1995), and designing an MSc degree in Quality Management at the University of Portsmouth (Seow and Moody, 1996). In Sweden, a QFD process was used to develop a Mechanical Engineering Programme which was more responsive to changes in industry (Nilsson et al, 1995). Of particular relevance to industrial engineers is the QFD approach used to improve IE education quality at the Middle East Technical University in Turkey (Koksal and Eggman, 1998). In the case described in the following section, a three-phase modified QFD process was adopted to provide a structured, integrated approach to developing an integrated suite of engineering courses to enhance a business school curriculum.

3.1.2 Case Study – Engineering for Business

The School of Business and Industry (SBI) at Florida A&M University (FAMU) was faced with the challenge of developing a suite of Engineering for Business courses for integration into its business curriculum. Among the benefits envisaged to be reaped by the students were an increased awareness of engineering and technology fundamentals, improved teamwork skills, and enhanced analytical and logical thinking. To realise these benefits, careful attention must be given to curriculum planning to maintain the quality and effectiveness of the programme. In this case, the modified three-phase QFD framework shown in Figure 1 was applied to facilitate the development of an integrated Engineering for Business curriculum.

The three-phase QFD process is used to provide a structured, integrated approach to curriculum planning proceeded in the following phases:

- **Phase 1: Course Planning** - which prioritised the teaching methodologies best suited to deliver critical competencies to students;
- **Phase 2: Course Design** - which identified and prioritised the engineering tools and techniques to be incorporated into the curriculum;
- **Phase 3: Course Implementation** - which assigned the preferred engineering tools and techniques to specific Engineering for Business courses.

Successful implementation of this integrated planning process required the conduct of several stakeholder focus groups, surveys and panels to arrive at a consensus on programme enhancements. Table 2 summarises the final QFD matrix which identified the four courses proposed and indicated the engineering tools and techniques to be covered in each course. The robustness of this planning methodology was confirmed via sensitivity analysis.

3.2 Bridging the Theory/Practice Gap and Building Innovation

3.2.1 Overview

To be effective, IE education and training programmes in the Caribbean will be well advised to...
pursue the ideal of a seamless curriculum and aim for the effective integration of teaching, research and service activities. This concept is illustrated in Figure 2. Careful attention should be given towards recruiting the right mix of academically and professionally qualified faculty and in pursuing research projects which promote the seamless integration of teaching, research and service. In the case study below, we illustrate how this concept can drive industry/academia collaboration on projects which can promote research of impact and lead to the development of topical teaching material and case studies while providing an opportunity for faculty and students in academia to deliver much needed services to industrial organisations.

![Figure 2. Integration of Teaching, Research and Service in IE Education and Training](image)

**3.2.2 Case Study – NASA Langley**

Over the years, NASA-Langley Research Center (NASA LaRC) in the USA has developed a large portfolio of patents and has been interested in attracting investors to commercialise the more promising ones. One of the technologies identified for review was an Ice Thickness Gauge Technology which addressed the hazards posed by ice build-up on aircraft, buildings and other structures. This technology offered promise because of its ability to distinguish between ice and water and to measure the thickness of ice with a high level of accuracy. Its versatility suggested good potential for deployment in a wide range of applications. These factors prompted its selection as a candidate for a preliminary technology commercialisation study. A team of faculty and students from Florida A&M University was contracted to assess the feasibility of developing a commercially viable business venture using the NASA Ice Thickness Gauge technology. The methodology adopted is summarised in the flowchart in Figure 3.

In the Market Analysis phase of the study, feedback from brainstorming activities of a large novice panel was combined with input from an expert panel of engineering professionals to identify the more promising applications of the technology. In this case, the aircraft industry was identified as the most promising target for the ice gauge technology. In a concurrent Technology Assessment phase, screening heuristics were used to identify a shortlist of more competitive patents. These finalists were then compared using a scoring model to gauge the competitive advantage offered by the technology over competing patents. The NASA technology was found to offer some advantage over the major competitors. Next, in the Financial Evaluation phase, a deterministic financial model was formulated to assess the technology’s profitability potential over a five-year study period based on cashflow forecasts of revenue and expenditure in the most likely scenario.

Finally, in the Risk Analysis phase, the risk associated with the commercialisation effort was assessed using sensitivity analysis, scenario analysis and simulation modeling. In this case, the outcomes included the development and implementation of a novel framework for conducting technology commercialisation studies (Benjamin, 2006), preparation of a case study in technology commercialisation for use in Industrial Engineering and Engineering Management classes, several IE conference presentations and journal publications (Benjamin et al, 2005), and written commendations from NASA on the high quality of service provided to the NASA Langley Research Center by the team of faculty and students.

**3.3 Developing Strategic Alliances**

**3.3.1 Overview**

In its 1998 Competitiveness Report (Ministry of Trade and Industry, Singapore 1998), Singapore, a small island state agreed that the goal of its human capital development efforts was “to be a world-class workforce in the 21st century”. These ideas have been adopted in Trinidad and Tobago’s Vision 2020 Report on Science and Technology (2005), and are summarised in Figure 4.
Table 2. QFD Chart - Course Implementation Phase

<table>
<thead>
<tr>
<th>The WHATs: Engineering Tools and Techniques</th>
<th>The HOWs: Proposed Courses</th>
<th>Fundamental Engineering Concepts</th>
<th>Management Engineering I</th>
<th>Management Engineering II</th>
<th>Management of Technology</th>
<th>Importance 1 - little; 5 - great;</th>
<th>Row Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Computer Aided Design</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Facilities Planning</td>
<td>1</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Value Engineering</td>
<td></td>
<td></td>
<td>3</td>
<td>3</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Quality Control</td>
<td>3</td>
<td></td>
<td>3</td>
<td>3</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Ergonomics</td>
<td>3</td>
<td></td>
<td>3</td>
<td>3</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Simulation Modeling</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Multi-Criteria Decision Models</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Mathematical Programming</td>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Scheduling</td>
<td></td>
<td></td>
<td>3</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Network Analysis</td>
<td></td>
<td></td>
<td>9</td>
<td>4</td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Expert Systems</td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Artificial Neural Networks</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>13. Fuzzy Logic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Quality Function Deployment</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Project Management</td>
<td></td>
<td></td>
<td>3</td>
<td>9</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Risk Analysis</td>
<td></td>
<td></td>
<td>3</td>
<td>9</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Computer Programming</td>
<td>9</td>
<td>3</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Score</td>
<td>108</td>
<td>106</td>
<td>108</td>
<td>95</td>
<td>417</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>25.90</td>
<td>25.42</td>
<td>25.90</td>
<td>22.78</td>
<td>100</td>
<td></td>
<td></td>
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<tr>
<td>Rank</td>
<td>1=</td>
<td>3</td>
<td>1=</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rating Scale: 1 – Weak 3 - Medium 9 - Strong

Strategic industry/academia alliances can assist in equipping the industrial engineers in the Caribbean with these key skills and competencies which are of critical importance in today’s global, competitive and demanding market place. This may require refocusing of the organisational culture of the region’s universities to be entrepreneurial (Grigg, 1994).

Universities have recognised the need to develop new approaches to educate the engineering manager (Kocaoglu, 1994). At Wayne State University (WSU), a leader in industrial engineering and engineering management research and education in the US automotive industry, the Engineering Management Master's Program (EMMP) is one of several programmes in the USA that cross disciplinary boundaries between business and engineering, and are characterised by strategic alliances with industry partners. For over a decade, WSU’s Industrial and Manufacturing Engineering (IME) Department, in partnership with Ford Motor Company and Visteon Corporation, has delivered the Engineering Management Masters Program (EMMP), an innovative applied research and education programme (Chelst et al., 1998). EMMP is a three-year masters degree programme with more than 100 current students and 400 graduates who have been selected by their companies as future leaders. This collaborative programme involving Wayne State University and industry partners (such as Ford Motor Company and Visteon Corporation) targets experienced working engineers. These students study part-time for three academic years (and two summer terms) and earn a single 42 credit degree: Master of Science in Engineering Management. The first two years involve engineering, business and systems coursework. The final year is dedicated to a leadership research
project. One such project is described below involving a team of faculty from Wayne State University and Ford Motor Company (Chelst et al., 2001).

3.3.2 Case Study – Ford Motor Company
The prototype vehicles that Ford Motor Company uses to verify new designs are a major annual investment across its global operations. A team of engineering managers studying for graduate degrees in a Wayne State University programme taught at Ford adapted a classroom set-covering example to begin development of the prototype optimisation model (POM). Ford uses the POM and its related expert systems to budget, plan, and manage prototype test fleets and to maintain testing integrity, reducing annual prototype costs by more than USD250 million. POM’s first use on the European Transit vehicle reduced costs by an estimated USD12 million. The model dramatically shortened the planning process, established global procedures, and created a common structure for dialogue between budgeting and engineering.

Ford uses POM-Predictor to plan for prototype budgets for all the vehicle programmes of Ford Lincoln, Mercury, and Jaguar and will use it for Volvo as soon as it is better integrated into the Ford Motor Company. The model designed a fleet that was 25 percent smaller than originally estimated. Over the 1995-2000 period, the cost of developing prototypes was reduced from over USD1 billion per year by more than USD250 million. During the same period, Ford increased its yearly offering by more than 20 percent. POM-Predictor enabled top management to explore and revise its assumptions about vehicle programmes so as to develop a realistic plan that realised cost savings of 25 percent.

3.4 Developing Campus-wide Entrepreneurship Programmes
3.4.1 Overview
Katz (2003), in chronicling the evolution of entrepreneurship education in the USA from 1876-1999, suggested that the field had reached maturity and expected growth to occur outside business schools and outside the USA. However, Schramm (2006) has asserted that US colleges, universities, and business schools, should be at the very heart of entrepreneurial capitalism and should be making bigger contributions to the changing economic landscape. He argues that higher education should graduate intellectually curious students prepared to make innovative contributions to society and the economy. In support of this philosophy, the Kauffman Foundation, a leader in forging entrepreneurial initiatives on university campuses in the USA, seeks to foster “a society of economically...
independent individuals who are engaged citizens, contributing to the improvement of their communities” (www.kauffman.org).

3.4.2 Case Study – Florida A&M University

In an effort to provide an environment for the cross-fertilisation of entrepreneurial ideas, a large business school in the USA, accepted the challenge of leading a campus-wide initiative in Entrepreneurship. Success would require the dismantling of artificial barriers that have traditionally limited the unfettered cooperation and open collaboration that could promote breakthrough changes.

Students would not only acquire traditional business management skills but also obtain an increased awareness of the impact of innovation on the successful planning and implementation of new business ventures. To realise these benefits, careful attention was required during the planning stages to identify the relevant strategies that would represent the best fit with the university’s mission while meeting often conflicting stakeholder expectations. Figure 5 shows the framework proposed to involve all academic departments in a campus-wide entrepreneurship initiative aimed at encouraging the development technology-based ventures, lifestyle businesses, and social entrepreneurship.

Figure 5: Framework for a Campus-Wide Initiative in Entrepreneurship

Figure 6 summarises the single-phase Quality Function Deployment framework developed to design the campus-wide entrepreneurship initiative. This process enabled the prioritisation of the entrepreneurship development strategies best suited to meet the needs of the various stakeholder groups.

4. Future Directions in the Caribbean

4.1 Determine Programme Focus

Contemporary issues related to the internet, globalisation, changing demographics, national security, lean and green manufacturing, and entrepreneurship present challenges and opportunities for IE educators in the Caribbean. To ensure an effective response, key stakeholders in the Caribbean community must be engaged in determining the appropriate focus of the region’s IE programmes. Arriving at a consensus on the specific competencies to be inculcated in IE graduates and the mechanisms to be put into place to foster inter-institutional co-operation and collaboration can assist in determining the appropriate focus of IE programmes in the Caribbean. This will enable decisions to be made on issues such as the research agenda to be pursued, new curriculum offerings to be
developed, and the emphasis to be placed on online courses.

The region’s government, business and industry stakeholders have suggested that the UWI graduate has been lacking in the ‘softer skills’ which often enable students to better transition to the “world of work” or the engineering profession. The ASME Professional Practice Curriculum (ASME International, 2006) summarised in Figure 7 provides an excellent benchmark for adoption by the IE faculty at UWI and other engineering institutions in the Caribbean.

![Figure 7](image)

**Figure 7.** The ASME Professional Practice Curriculum
Source: Abstracted from ASME International (2006)

In recent years there has been progress in the Faculty of Engineering with respect to teaching and learning so as to better prepare graduates through enhanced skills in Communication, Leadership, Team Building and Project Management, Professional Ethics, Innovation and Entrepreneurship and Health, Safety and Environment. The IE programme and its staff of the Faculty of Engineering of the UWI should be a leading player in these efforts as there is much more to be done.

In developing an IE research agenda, care should be taken to ensure that the R&D efforts of the IE faculty are complementary to the undergraduate and postgraduate teaching that is being delivered and continue to focus on helping business and manufacturing enterprises in the Caribbean particularly the SMEs, to compete effectively not only in the local context, but also in the wider regional and global marketplace. Also required are the development or adoption of new methods for learning and the promotion of wider access for undergraduate and postgraduate education through new Computer Aided Educational technologies.

### 4.2. Developing Strategic Alliances

In this increasingly inter-connected world, UWI’s IE programme must pursue strategic alliances with the professional engineering organisations locally, regionally and internationally, e.g. the Association of Professional Engineers of Trinidad and Tobago (APETT) and the other Regional Professional Engineering Organisations, the Board of Engineering of Trinidad and Tobago (BOETT), the Council of Caribbean Engineering Organizations (CCEO), Institute of Industrial Engineers (IIE), the Institution of Mechanical Engineers (IMechE, UK), and American Society of Mechanical Engineers (ASME), etc. It must also aggressively establish links with
local and regional industries, and academic institutions in other countries.

The creation of the Centre for Enterprise Research Integration (ERI) within the Department of Mechanical and Manufacturing Engineering of the UWI whose principal objective is “to provide an environment for teaching, research and extension in areas such as e-Enterprise Operations (e.g. e-logistics, e-supply chain and e-business) and Computer Integrated manufacture, through the integration of Simulation, Shop Flow Control, Instrumentation, and Business Enterprise Management Systems” and which would work closely with Industry, is a step in the right direction. The Faculty’s Engineering Institute can also play a major role in creating linkages with Government, business, and industry.

5. Discussion and Conclusion

IE education and research in the Caribbean is at a critical stage in its ongoing evolution as it now needs to re-position itself to address several major challenges and exploit opportunities. The case studies described in this paper report strategies adopted at institutions in the USA in the hope that these stimulate a search for innovative enhancements to IE programmes in the Caribbean.

Our review of UWI Faculty of Engineering with its experienced faculty, established undergraduate and graduate programmes, supportive and faculty-friendly environment suggests that it has great potential to develop a world-class industrial engineering programme. To date, UWI has provided IE education and training for a large number of very successful professionals who now occupy leadership roles in business, academia, and government organisations in the Caribbean. This paper seeks to contribute to the dialogue and debate necessary to ensure the continuous review, re-examination, and re-visiting of the IE programme’s mission to better meet the challenge of developing industrial engineers who will continue to have a significant impact on the sustainable, socio-economic development of the Caribbean region.

UWI, a leader in IE education and training in the Caribbean, should aim to be agile by developing nimble and responsive programmes, adopt the entrepreneurial university model, encourage academic rigor by delivering challenging course content, pursue strategic alliances with professional organisations, companies and other universities, and adopt strategies to recruit, inspire and retain a cadre of highly motivated IE faculty. Ongoing efforts are required to ensure a careful review of global trends in IE, arrive at a consensus among stakeholders on the way forward, and boldly implement the new vision.

6. References


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**Biographical Notes:**

Colin O. Benjamin is an Eminent Scholar and the Anheuser-Busch Professor of Engineering Management at Florida A&M University in the USA. He has had several years of international teaching, industrial and consulting experience. He received a PhD in Industrial Engineering from the University of the West Indies, an MBA from the Cranfield Institute of Technology, UK, and an MSc in Engineering Production and Management from the University of Birmingham, UK. He is a Chartered Engineer in the UK and is a Senior Member of the Institute of Industrial Engineers in the USA.

Leslie F. Monplaisir is Associate Professor and Director of the Engineering Management Masters Program offered exclusively to Ford Motor Company and Visteon with an annual budget of over one million dollars. His research interests include: Collaborative Product Design and Development (CPDD), Collaborative and Distributed Engineering and Design, Integrated Manufacturing and Design of Agile Manufacturing Systems, and modeling tools to support concurrency in product realization. He holds an MSc in Integrated Manufacturing Systems from University of Birmingham (UK) and a PhD in Engineering Management from the University of Missouri-Rolla. He is a Senior Member of the Institute of Industrial Engineering (IIE).

Clement K. Sankat is the Principal of the University of the West Indies, St. Augustine Trinidad and a Professor in the Department of Mechanical and Manufacturing Engineering. He has served as Dean of the Faculty of Engineering, Head of Department, Deputy Dean (Graduate Studies and Research) and Campus Coordinator, Graduate Studies and Research. He received the BSc (1st Class Hons) and MSc degrees in Mechanical Engineering from UWI and the PhD in Engineering from the University of Guelph, Canada. He is a Chartered Engineer (CEng), Fellow of the Association of Professional Engineers of Trinidad and Tobago (FAPETT) and a Fellow of the Institute of Agricultural Engineers of the UK (FI AgrE).

Denise Margaret Thompson is Programme Professor for the Centre for Innovation, Development, Enterprise and Strategy (C-IDEAS) at the University of Trinidad and Tobago. She received a BSc (Hons) in Industrial Engineering from the University of the West Indies (UWI), the MSc and Engineer degrees in Industrial Engineering and Engineering Management from Stanford University, USA and a PhD in Industrial and Management Systems Engineering from the University of South Florida, USA. Her research interests include the role of technology entrepreneurship in economic and social development and creativity and technology innovation in development. She is a Senior Member of the Institute of Industrial Engineers of the USA and a member of the International Council for Small Business.

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