



# INTEGRATED APPROACH TO MASTERS PROGRAMME DELIVERY IN MANUFACTURING AND DESIGN ENGINEERING AT UTT

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**Abstract:** Translating theory into practice at the university level is easier said than done. Students often tend to experience difficulty in the application of knowledge learnt, as they seem to be accustomed to learning theory by rote and simply repeating it for the purpose of assessments. A somewhat different approach has been taken by the Design and Manufacturing Engineering (DME) Unit at the University of Trinidad and Tobago. In its BAsC and MSc offerings, the DME Unit has made the application of knowledge learnt in the various courses offered a key feature of its programmes. The focus of this paper will be on the MSc programmes offered by the Unit. The DME Unit currently offers two Masters programmes, one which focuses on management (Innovation, Manufacturing Management and Entrepreneurship – IMME) and another which focuses on design (Innovative Design and Entrepreneurship – IDE). These programmes are designed with a view to achieving several outcomes, including fostering the entrepreneurial spirit of students with the intention that they will start businesses at the end of their course of study, thereby commercialising any product or service they develop during the programme; developing their management capabilities, which prepares them for higher level positions and responsibilities at their places of work; immersing students into real-time, problem-based scenarios at companies over the period of a semester to allow them to act as consultants in a work environment different to their own; and nurturing their engineering design capabilities for new product development, with the intention that any such design produced will eventually be commercialised. In light of these outcomes, both programmes share common features in the courses that are covered. Such courses focus on management, entrepreneurship, business development and industry immersion. This paper will highlight the successes of this approach in both programmes.

**Keywords:** *Design, Design and Manufacturing Engineering, Management, Masters Programmes, University of Trinidad and Tobago.*

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## 1. Introduction

Engineering, as a subject matter, is inherently practical in nature. It requires the application of knowledge (theory) to a real-life context or simulated scenario (practice). Translating theory into practice at the university level, however, is easier said than done. Students often tend to experience difficulty in the application of knowledge learnt, as they seem to be accustomed to learning theory by rote and simply repeating it for the purpose of assessments. It is for this reason that an integrated approach has been adopted by the Design and Manufacturing Engineering (DME) Unit at the University of Trinidad and Tobago. In its undergraduate and postgraduate offerings, the DME Unit has made the application of knowledge learnt in the various courses offered a key feature of its programmes. The focus of this paper will be on the postgraduate programmes offered by the Unit.

The DME Unit currently offers two Masters programmes, one of which focuses on management (Innovation, Manufacturing Management and Entrepreneurship – MSc IMME) and another which focuses on design (Innovative Design and Entrepreneurship – MSc IDE). As integrated engineering and management programmes of study, they are designed with a view to achieving several outcomes, among which include: fostering the entrepreneurial spirit of students with the intention that they will start businesses at the end of their course of study, thereby commercialising any product or service they develop during the programme; developing their management capabilities, which prepares them for higher level positions and responsibilities at their places of work; immersing students into real-time, problem-based scenarios at companies over the period of a semester to allow them to act as consultants in a work environment different to their own; and nurturing their engineering design capabilities for new product development, with the intention that any such design produced will eventually be commercialised. In light of these outcomes, both programmes share common features in the courses that are covered. Such courses focus on management, entrepreneurship, business development and industry immersion. These courses are generally more reflective of the softer skills that graduates are expected to have when pursuing management or supervisory positions in engineering business environments. While the programmes are not necessarily very heavily engineering based, the application of knowledge in the management courses is equally important, as this is coupled with the technical skills in both programmes to produce management-ready graduates for technical environments. This paper will highlight the successes of this approach in both programmes.

This paper begins with a brief literature review, followed by a review of the common courses offered to both degrees. Each review will provide a brief description of the course and mode of delivery; intended learning outcomes and how assessments achieve this; examples of actual assessments requiring practical application of knowledge gained in the course; and, finally, examples of successful application of knowledge gained as covered in the most recent course offering. This will be followed by a brief discussion of the findings and a conclusion.

## 2. Literature Review

Employers want work-ready graduates. In the classroom setting, students learn theory but are generally unable to apply it unless they have been given some practical or simulated setting in which to do so. The gap between theory and practice is made very apparent when graduates enter



the workplace. Theory that is supported by practice makes understanding, and hence learning, far more likely [1]. Problem-based learning (PBL) provides a very practical means by which students may apply theory. Martínez León [2] noted that PBL is a student-driven, teacher-facilitated approach to learning. Projects can be industry-led, typically by local companies or firms, or student-initiated. Research showed that students feel more involved in the learning process when PBL is used as they are actively participating in the application of knowledge [2]. Moreover, among the reported outcomes of PBL are a greater understanding of a topic, increased student engagement and motivation to learn, and better researchers and problem-solvers [2].

For industry projects, students are placed into “consultancy teams” to analyse a real-time challenge being faced by a company and providing recommendations for implementation [1]. They may or may not receive a stipend, but they are required to apply knowledge gained in the classroom setting to the identified challenge and problem solve. In this way, abstract knowledge transforms into concrete experience through the dynamics of student groups who become working consultancy teams [1]. It takes students beyond the classroom into the realms of real businesses functioning in highly pressurised environments that must constantly identify problems and seek solutions, improvements and sound decision making [1]. With this sort of collaborative approach, students’ work and research at universities are linked to industry’s real needs and, sometimes, government expectations [1]. Students’ identities go from “student” to “student plus engineer” in these settings [3]. Such collaborative efforts can help in the redesign of university curricula to make them more relevant to industry and general national development goals. It has been noted that in the university environment, theory and abstract concepts remain exactly that and without concrete experience and the opportunity to experiment and test ideas, whether through real or simulated means, full learning is difficult to achieve [1]. University-industry partnerships encourage blended knowledge delivery with a larger element of practical sessions, typically framed in a problem-based learning approach [2]. This, in turn, brings more experience in real-world environments to the classroom setting [2]. These university-industry partnerships have proven invaluable to not only enhance knowledge transfer and understanding but also provide opportunities for students to gain practical experience [4].

Application of knowledge to simulated settings is equally important. This can be done through project-based assignments or laboratory work. Such projects should be used to simulate the characteristics of real-world problems such as the complexity, uncertainty, multi-solutions and constraints [5]. Students’ soft skills, such as leadership, communications, teamwork, planning and organisation are developed or improved through project work as well [5]. Students given the opportunity to solve actual engineering problems in simulated industrial conditions gain exposure to what will be expected of them after they graduate [3]. Experiential learning and cooperative education provide students with the necessary tools to succeed in the workplace by simulating their future working environment [5]. Simulations try to establish an environment under which students are exposed to the real-world scenarios that they will encounter after graduation, and are taught how to learn and apply knowledge to solve practical engineering problems [5]. In a case study conducted at a Chinese university for a joint educational project between China and Germany, the authors found that in engineering education, (1) lecturing alone is not sufficient, (2) students benefit from interactive hands-on experiences, and (3) experiential, team-based learning involving student, faculty and industrial participation enriches the educational process and provides tangible benefits to all [5]. Simulations and experiential learning require context and it is for this reason



that formal learning in the classroom is important because it gives students the structures, concepts and theories that support the real-life experience and learning. Experiential learning is effective and reinforces formal learning because it becomes personal [1].

Even in the application of knowledge using case studies, students develop important skills. Case studies illustrate key theories that allow students to think productively about concrete experiences [6]. They enhance students' ability to learn from their own experiences as they employ theoretical concepts to illuminate a practice problem or situation and practice how to think professionally about real problems and situations [6]. In allowing for the application of theoretical concepts to be demonstrated, case studies help bridge the gap between theory and practice. They also encourage active learning; provide an opportunity for the development of key skills such as communication, group working and problem solving; and increase the students' enjoyment of the topic and hence their desire to learn [7].

Integrated courses enable students to learn meaningful sets of information, which are more easily retained and applied to other situations [5]. The Chinese case study found that combining engineering science and practice prepares graduates well for industry or for continued academic work [5]. The study also concluded that the comprehensive and collaborative application of various subjects or disciplines is necessary for students to solve a real world problem [3]. Linkages between course offerings within a programme of study, therefore, becomes very important. While courses are generally independent (except where they might be a prerequisite course), inherent relationships exist between various modules, so an integrated knowledge network can be formed [3]. This might be reflected in the required application of knowledge for assessments among courses.

An integrated approach to programme delivery in engineering management programmes allows for replicating the work conditions in which students will be exposed to after graduation; appropriately balancing the theoretical, foundational knowledge with hands-on, real-world experiences; and promoting academia-industry synergistic collaborations [2]. Combining theory and practice brings a balanced approach to learning [1]. It has been found that this approach makes the students well-prepared to transfer from university to industry smoothly and successfully [3], which should be the overriding goal of any university programme.

### **3. Common Courses**

There are eight courses common to the two postgraduate programmes which either require the application of knowledge to a real-life context and/or a simulated scenario. These courses are Business Strategy and Marketing; Entrepreneurship; Industry Design Project; Industry Project; Industry Management Project; International Study Tour; Leadership and Human Resource Management; and New Venture Proposition [8, 9, 10, 11, 12, 13, 14, 15].

#### **3.1 Business Strategy and Marketing**

The Business Strategy and Marketing course is a three (3) credit course that addresses strategy formulation, implementation and evaluation as key elements in determining the competitive success of companies [8]. The goal is to expose graduates to general strategic management frameworks with specific focus on two functional-level strategies: Manufacturing and Marketing.



The course is divided into three (3) broad components. The introductory component explores strategy definitions and strategic management concepts. The middle component of the course introduces students to fundamentals of manufacturing strategy, focusing on flexibility and quality objectives of manufacturing and emphasises two key manufacturing decision areas of performance measurement and the Make vs. Buy decision. The final component addresses the fundamentals of marketing, via an exploration of the meaning of marketing, the evolution of marketing as well as examining a number of marketing tools and techniques to ensure that students have a comprehensive understanding of marketing strategy.

This co-taught course is presented in a modular format with approximately 70% of the course being delivered online through “Read, Watch and Do” sections. This includes assignments, quizzes and other relevant references, sites, videos/podcasts, discussion forums and reading materials to aid further understanding of concepts. The remaining 30% of academic delivery is provided via face-to-face instruction consisting of activities similar to the online method. Learning outcomes require students to be able to explain the concept of strategic management; describe the manufacturing objectives and decision areas in a company’s manufacturing strategy; and explain the elements of a company’s marketing strategy. They must also be able to analyse the industry’s structure and company performance using fundamental strategic frameworks; evaluate the consistency between the decision areas and manufacturing objectives in a company’s manufacturing strategy; apply marketing tools and techniques; and, ultimately, prepare a marketing plan which encompasses all learning outcomes mentioned.

Students are continually assessed throughout the course. Assessment elements include the extensive use of discussions, in-class exercises, case studies and student-led modules. The student-led modules require groups to conduct research on a particular topic and present these findings via classroom presentations, zoom sessions, taped proceedings and/or via online apps such as CN Post. The topics include resource-based strategy; performance measurement and the make vs. buy decision; marketing mix and digital marketing strategy. Students must apply strategic frameworks such as SWOT, PEST, STP analyses and Porter’s Five Forces Model in exercises covered in other courses dealing with industry and company analyses. The discussions, in-class exercises, case studies and student-led modules allow for the development of communication skills and teamwork skills, as it relates to entrepreneurship.

The final assessment is a pre-seen case study provided one month in advance of the examination date to allow for preparation. The last case was based on a fictitious office furniture manufacturing company. Students are presented with the questions on the day of the exam. Using Bloom’s higher order skills, they are asked to assume specific roles and advance arguments, evaluate, explore, demonstrate, analyse and interpret in applying the course’s theoretical concepts to the situation at hand. Students applied the knowledge learnt well and displayed good critical thinking skills, connecting real world examples and business trends to the situations presented in the examination in the last course offering. Students were able to effectively apply theory and use a range of analytical tools to assess the issues presented and provide creative recommendations.

### **3.2 Entrepreneurship**

This three (3) credit course centres on the roles and processes of entrepreneurship, issues involved in the creation of new business ventures and includes a number of business components such as conceptualising, creating and managing a business as well as the process of developing new





products [9]. It is geared towards the graduates initiating the process of developing a new venture proposal starting with an Elevator pitch for presenting a business idea. The course incorporates creativity exercises to discern the balance of idea and opportunity generation. The elements of entrepreneurship are discussed and the students are taken through the process from simple finances to the steps involved in developing a full business plan.

The goal of the course is to provide a hands-on, real-world application of entrepreneurial principles through the use of tools that facilitate complex, dynamic decision-making using an entrepreneurial ecosystem approach. Learning outcomes include the ability to generate ideas/identify business opportunities; create and pitch a business idea; and attract investors, which require the use of some of the highest order skills as per Bloom's taxonomy. The course utilises a blended-learning approach, which combines face-to-face and online instruction. For the face-to-face instruction, the course is delivered over a 13-week period of 3-hour sessions, while the online instruction is conducted over the University's online learning platform, and consists of tutorials, discussion boards and other web-based materials.

The formal assessment of the module includes a combination of exercises; an elevator pitch and a final examination. Examples of the exercises include a Business Opportunity Concept Paper justifying how the proposed business venture met the four criteria of an opportunity. Another includes testing assumptions with live customers requiring students to go to a public place and give away five separate one dollar bills and to turn in a one-page reflective write up of their experience. The final examination consists of review, application, role play and case-study based questions. Overall, students demonstrated excellent application of knowledge and critical thinking, connecting real world examples, current environmental and business trends to the situations presented in the examination. Students were able to effectively apply theory and use a range of analytical tools to assess the issues presented and provide creative recommendations.

### **3.3 Industry Projects (Design and Management)**

Project work is the backbone of the two MSc programmes in IMME and IDE and students have the opportunity to practise the skills that have been developed in formal lectures during the year through a few projects [10, 11, 12]. The industry project courses, namely Industry Design Project, Industry Management Project and Industry Project form the vehicle via which this is done and are all four (4) credit courses. These are integrated course offerings that bring learnings from several courses into one project. Each project is based on a live company problem and students work in the company with the company staff to develop solutions to the problem. Each project has separate academic supervisors or teams of supervisors. On occasion, the chance to try out some of those solutions would be afforded to the students. Each project ends with the task of selling the ideas to senior management within the company. This takes the forms of a presentation, a poster and a formal report. These courses utilise a blended-learning approach, which combines face-to-face and online instruction. For the face-to-face instruction, the course is delivered over a 13-week period of 3-hour sessions, although such sessions are limited due to the nature of the course, while the online instruction is conducted over the University's online learning platform, and consists of web-based materials.

The programmes' emphasis is on developing the practical skills needed to manage in a modern manufacturing environment. Via these courses, programme members gain experience of solving



industrial problems which require critical thinking ability. This requires students to use Bloom's higher order skills, such as application, analysis and evaluation of theories and industrial contexts to provide recommendations. They also gain knowledge of industry from a fundamental level to the best practices adopted by leading companies and thus end up with a structured exposure to a range of industrial operations and environments in Trinidad and Tobago. Additionally, the students, working with all levels of employees, from shop floor to boardroom, learn the importance of teamwork and leadership necessary to obtain solutions in an industrial environment. The projects and students are assessed by both the UTT faculty and the company. Some of the attributes which are looked at are task management; the professional approach of the graduates; the final report, poster and presentation to the company; the quality of the approach to solving the problem, which takes into account how the teams worked within the different levels of the organisation to collect the appropriate data and analyse it; and, recently, a peer review is also included. The peer review has been added to encourage 360 degree assessment of the team.

Over the years more than one hundred projects have been done by students in the MSc programmes from South, to Central to North Trinidad and even Tobago. The areas covered have included process mapping, bottle necking and re-design, production management and control, logistics and supply chain, operations management, inventory management, product development, product design, marketing and strategy, technology management and even farm management. Soft skills, such as leadership, teamwork, and communication are inherent components of each project and key to the projects' success. Learnings from several other courses offered in the programmes are applied to the industry project courses. These courses represent integrated course offerings that bring knowledge gained from several courses into one project. In some instances, the students are required to conduct their own research into topic areas that have not yet been formally covered.

The students have given feedback that the learning acquired through these projects is invaluable as it affords many of them the opportunity to work on a 'real' problem. They have remarked that case studies, while giving some of the elements of such a project, still fall short. Some of the elements they have to deal with to solve the problem include scattered pieces of data, incomplete data, and late delivery of data; different personality types within the organisations; and different types of record keeping, if any. Some have even failed to triangulate the data collected. They understand at the end what it takes to operate within a local manufacturing environment. Many of the companies are often pleased with the results of the work and are pleased too to be able to contribute to the development of graduates who return to the industry job market for recruitment. It gives them an opportunity to ascertain what is available and what gaps need to be filled. The implementation rate of recommendations is at about 50%, mainly due to the cost of implementation and the longstanding financial crunch in the manufacturing sector. The aim is to have the companies not only implement but to engage the Unit's expertise in providing real engineering solutions.

### **3.4 International Study Tour**

International Study Tour is a four (4) credit course which aims to allow the students to visit countries where they study best practices from industries worth implementing in Trinidad and Tobago [13]. This is one of the integrated course offerings that brings knowledge gained from several courses into the assessments. This course utilises a blended-learning approach, which combines face-to-face and online instruction. For the face-to-face instruction, the course is



delivered over a 13-week period of 3-hour sessions, although such sessions are limited due to the nature of the course and the fact that learnings are drawn largely from other completed courses, while the online instruction is conducted over the University's online learning platform, and consists of web-based materials. Some of the topics covered during the face-to-face and online sessions include rapid plant assessment, travel and business etiquette, and personal budgeting.

During the international study tour of overseas companies, manufacturing plants and eco-establishments, students observe, first hand, technical, organisational, economic, educational and social aspects of industrial companies in the country visited and compare with those visited and/or researched in Trinidad and Tobago towards enhancing business profitability and developing globally competitive manufacturing opportunities locally. Over the years, the international study tour targeted specific areas, such as technological innovation, renewable energy, agro-processing, eco-tourism, ICT, manufacturing and operations and supply chain management. The learning outcomes of this course include Bloom's higher order skills and require students to explain the best practices as obtains in an international company; critique international management structures; and model and analyse business and design processes. These are achieved through three main assessments which include a pre-travel SWOT and PESTLE analysis of the country to be visited; in-country travel rapid plant assessments and debriefing session; and, finally, the report that brings all components together in the form of a group video.

The international experience similarly contributes to the non-academic life of the student, expanding the cultural learning experience, increasing the employability and advancing the career trajectory of the student for global/regional networking opportunities and career opportunities. The course not only serves to extend the profile and reach of the IMME and IDE programmes by the invaluable linkages forged, but also positively influences UTT's student enrolment rates in these programmes.

### **3.5 Leadership and Human Resource Management**

This three (3) credit course looks at the practice of leadership and strategic human resource management in organisations [14]. The underlying premise is that the exercise of values-driven, principled leadership enables organisations and their members to be effective and adaptive in order to achieve their desired results. Some of the areas of study include leadership styles, leadership theories, change leadership, Kolb's learning cycle and its importance in human resource management, the organisation and the impact of leadership styles on it, and recruitment and role definition within the organisation. The strategies employed in delivery include face-to-face sessions by faculty and industry personnel with the appropriate expertise, simulation via team-building exercises away from the classroom and in-classroom simulations. There is a great emphasis on using experiential learning techniques.

Using some of Bloom's middle and higher order skills, the learning outcomes include being able to differentiate between leadership and management, demonstrate an understanding of the impact of leadership styles on organisational performance and to explain the impact leaders have on organisational direction and success. This is assessed via a leader interview which the students are required to do and film with a local leader from industry. Students are tasked with preparing and following an appropriate interview protocol, after having done the necessary research, which will give them the requisite knowledge as stated before. They often find that in Trinidad and Tobago there is sometimes a "mix-up" of management and leadership where even perceived leaders think





that there is no difference. Some other knowledge that students are expected to gain include being able to actively contribute to strategic human resource initiatives in organisations and to describe principles of group dynamics and collaboration and apply them to improve group effectiveness. These learnings are assessed by a community development project. The students are tasked with pin-pointing the leader within a local community and adopting this community such that they may assist with a current challenge that they are having. The students generally work in small groups and choose communities that they live in to help. They work with the local regional authorities and the community centres who have leaders in order to ascertain what help may be needed. In the past, they have revitalised parks, built community bins for garbage, set-up a sick bay in a primary school and even conducted a toy drive for the paediatric ward in a hospital. In all the projects, they have had to learn skills in order to get these projects done and have to be actively involved as they had to implement the projects within the semester.

Finally, they are also expected to describe the elements of power and influence and be able to apply them to the development of an organisational strategy, explore their personal leadership characteristics and potential, and be consciously competent to use this self-knowledge to enhance existing leadership strengths and to acquire new leadership skills and link leadership with effective human resource practice. This is assessed by a book report of a biography of a leader whom they admire. They are expected to do some introspection and find a style of a leader which they like and do some research on this person. The students have found this task to be particularly helpful and it took some time for them to find a leader with whom they could identify personally and explore in terms of the skills he/she possessed and how those were used within government, a company, a community or even a home. The biographies reported on ranged from Steve Jobs to Steven Gerrard to a Cub Scout leader! They were all very telling about personalities and styles.

The above gave some very real examples of how “real” projects could make a difference, not only to the students’ learning, but to the industry and to the community. The UTT’s mission is to assist the local environment and this course was specifically geared to do that, as the country’s future leaders will come from these said students. Some of the projects had a monetary value, ranging from \$3,000 TTD to \$10,000 TTD and the students themselves raise all the necessary funds. They are thus taught to use skills from other courses, for example, their Entrepreneurship course, and apply where necessary. The course is worth three credits but the intangible benefits far outweigh this value and students have reported that they enjoy the learning and the work that they were able to do.

### **3.6 New Venture Proposition**

This is a six (6) credit course that sees the application of the knowledge students have gained throughout the duration of the programme from the various courses they have completed [15]. This is another one of the integrated course offerings that bring knowledge gained from several courses into one project. Students are required to use this knowledge to develop a new venture that will take the form of a business plan and presentation to be made to a group of investors. The business plan is a carefully considered and written document that pieces together elements presented in various modules during the course of the programme. It is expected that theory learnt from the following courses are reflected in the plan: Entrepreneurship, Business Strategy and Marketing, Leadership and Human Resource Management, Operations and Supply Chain Management, and Company Law. While the latter two courses are not common courses to both degrees, offered only



to the Management students, the teams are mixed with students from both streams who assist with the skills required from those courses. The Entrepreneurship course is a pre-requisite to New Venture Proposition. This course utilises a blended-learning approach, which combines face-to-face and online instruction. For the face-to-face instruction, the course is delivered over a 13-week period of 3-hour sessions, although such sessions are limited due to the nature of the course and the fact that theoretical information is drawn largely from other completed courses, while the online instruction is conducted over the University's online learning platform, and consists of web-based materials, similar to International Study Tour.

In addition to being able to apply knowledge gained from other courses offered in the MSc programmes to the creation of a business plan, learning outcomes require students to understand and explore the resources available for creating a new venture; evaluate the feasibility of a new business venture; and produce a business plan as a means of seeking funding. These reflect in large part Bloom's higher order skills and is assessed through the business plan document. In evaluating the feasibility of the new business venture, students are required to draw on their learnings from the various other courses noted earlier and apply them here. Students are also required to prepare and present a business pitch as a means of seeking funding which allows them to develop professional presentation skills. This is assessed through the oral presentation.

This course has produced many very interesting business propositions, including online apps for event planning and wardrobe management, a mobile barber shop, a tilapia farm, 3D printing services, herbal tea production, among numerous others. In preparing the various feasibility studies and conducting market surveys, students are able to effectively apply the theory they have learnt in their other courses to produce a practical outcome: the business plan. As group-based work, the students also develop softer skills, such as time management, leadership, teamwork, communication, conflict management and resolution, and collegiality. They are tasked with finding an industry expert who can advise them on their particular business ideas; they are meant to maintain this relationship over the duration of the course. These advisors are invited to the final assessment (the presentation), to both listen to the presentations and provide the lecturers with feedback on the group's interactions with them as well as on the project itself. Both the students and the advisors find this relationship useful, as the students get hands-on experience from an industry expert, while the industry expert is allowed to share his experience with the group and act as a mentor. Some students go on actually to establish the businesses for which they submitted plans and commercialise their product or service.

#### **4. Discussion**

Of the eight (8) courses reviewed, five (5) are integrated course offerings that combine theory from several courses into one project: Industry Design Project, Industry Management Project, Industry Project, International Study Tour, and New Venture Proposition. What faculty have found is that such an approach reinforces learning as it requires constant (re)application of concepts and theories taught throughout the duration of the programmes to each individual course [3, 4]. Using the project-based assessments, students are required to apply problem-solving and critical thinking skills to real-life and real-time manufacturing situations which illustrates their true understanding of the materials presented to them in the classroom setting. A task as seemingly simple as data gathering at companies allows students to recognise that, in industry, operational challenges often override most other company requirements, such as data management and the implementation of



data management systems, and that they may have to find more innovative ways of collecting data. Despite daily operational challenges, though, companies are often quite willing to facilitate student groups as it achieves two goals: the company can have an organisational challenge solved based on theoretical knowledge (usually one for which they do not have any unemployed resources which they can allocate to it) and students are allowed to put theory into practice, making the learning process real and relevant to them. Engineering practitioners note the need for closer engagement between industry and academia [4] and immersing students into companies over a semester is certainly one means of doing so.

For other project-based assessments not based in a company, students work largely in groups with limited face-to-face sessions, such as for International Study Tour and New Venture Proposition. Again, because these are integrated course offerings that bring learnings from several courses into a single project, it reinforces learning [1, 2] and requires application of knowledge gained from other courses [6, 7]. One of the interesting facets of the International Study Tour course is that students will provide a comparison of best practices as applied to the companies of the foreign country under study to the practices of local manufacturing companies. In doing so, they make recommendations for best practices in the industry that is being reviewed. This requires practical knowledge of the companies' operations and production and subsequent application of the theory they have learnt.

Leadership and Human Resource Management is not an integrated course offering, but certainly feeds into several of the other courses, such as the various Industry Projects, International Study Tour and New Venture Proposition. This course has individual and project-based assessments that allow students to develop many of the softer skills required for persons seeking to move up the corporate ladder. Skills such as leadership, communication, teamwork, planning and organisation [5] are developed or improved through the projects assigned for this course. Students also learn how to relate to senior management and become skilled at time management, conflict management and resolution, and collegiality.

The use of case studies as a means of assessment also forces students to apply the theory they have learnt to solve the problem presented [6, 7], such as used in Business Strategy and Marketing and Entrepreneurship. Faculty have found that students applied the knowledge learnt well and displayed good critical thinking skills, connecting real world examples and business trends to the situations presented in the case studies. This means that they can now view global business and manufacturing developments through a critical lens. Students were able to effectively apply theory and use a range of analytical tools to assess the issues presented and provide creative recommendations.

In informal and formal discussions with members of industry, they have indicated that the approach adopted by the DME unit of integrated course offerings and requiring the application of knowledge to real-life contexts or simulated scenarios is successful as graduates from the MSc programmes are generally work ready and require little training [3]. Similar to Martínez León's [2] findings, the two MSc programmes enhance students' preparedness for work environments that require collaborative, negotiating, planning, research, data-driven and organisational skills, all of which were applied and practised in the various projects.

As noted in the introduction, both MSc programmes are designed with a view to achieving several outcomes. The first is fostering the entrepreneurial spirit of students with the intention that they



will start businesses at the end of their course of study, thereby commercialising any product or service they develop during the programme. This particular outcome is achieved in the following courses: Business Strategy and Marketing, Entrepreneurship, and New Venture Proposition. The second is developing their management capabilities, which prepares them for higher level positions and responsibilities at their places of work. This is achieved in Leadership and Human Resource Management, the various Industry Projects and International Study Tour. The third is immersing students into real-time, problem-based scenarios at companies over the period of a semester to allow them to act as consultants in a work environment different to their own. This outcome is realised through the various Industry Project courses. The fourth one mentioned is nurturing their engineering design capabilities for new product development, with the intention that any such design produced will eventually be commercialised. This outcome is attained in New Venture Proposition and, to a lesser extent, Industry Design Project.

## 5. Conclusion

The integrated approach to educational programme delivery is by no means novel but it is not applied by all educational institutions or programmes of study. Nevertheless, the application of this approach to the two MSc programmes offered by the Design and Manufacturing Unit at the University of Trinidad and Tobago has yielded positive results for the graduates of the programmes, the university and industry. This is drawn from anecdotal evidence and is an area that requires further investigation to produce empirical data. The integrated approach to course offerings and the practical nature of the assessments used allow for the constant reinforcement of concepts and theories learnt in the formal classroom setting and, equally importantly, the application of this knowledge to real contexts or simulated scenarios, both of which permit experiential learning by the students. It is these two key features of the MSc programmes that have allowed the DME Unit to produce work-ready and management-ready graduates who can effectively apply theory to practical situations, thereby providing useful and implementable solutions.

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