Producing Valuable Protein Concentrates from the Cassava Crop's Post Harvest Waste Products

Annaleise H.L. Aiken[1], Ian L. Thompson[2], Diptendu Chatterjee[3] and G. Harvey Anderson [4]

[1,2] Department of Chemistry, Faculty of Science and Technology, The University of the West Indies, Mona Campus, Jamaica;
[1]Email: annaleise.aiken@mymona.uwi.edu
[2]Email: Ian.Thompson@uwimona.edu.jm;
[3,'4] Department of Nutritional Sciences, Faculty of Medical Sciences, University of Toronto, Canada.
[3]Email: diptendu.chatterjee@sickkids.ca;
[4]Email: Harvey.anderson@utoronto.ca

Abstract: *Cassava (Manihot esculenta Crants) is a valuable crop which is widely used for its starch-rich roots and whose economic potential is slowly being recognised in the Caribbean. The discarded leaves of the cassava plant account for over 10% of post-harvest waste mass. However, the leaves are reported to be protein rich- ranging from 14-40% (dry weight basis) depending on plant variety and maturity. This study presents a comparative evaluation of the leaves and leaf protein concentrates (LPCs) of Colombian (MCOL22 and CM849) and Jamaican (Rockwood) cassava varieties for dietary protein supplementation potential. LPCs present a convenient vehicle for inclusion of plant proteins in human diets. The crude protein (CP), soluble protein and amino acid (AA) content of these leaves were determined at 5, 7 and 9 months after planting. The LPCs were produced from 9-month leaves by low-heat coagulation. The CP content (dry weight basis) of the Colombian varieties -MCOL22 and CM849 are highest at 9 months after planting- 27.5± 0.7% and 28.1± 0.2% respectively, while the CP of Jamaican variety - Rockwood is highest at month 5 at 26.8± 0.4%. The LPCs of these varieties have a CP of 39.1± 0.1%, 42.9± 0.2% and 38.2± 0.2%- an average CP enrichment of 48.4% relative to the leaves from which they are prepared. The AA content of the leaves and LPCs were determined by HPLC analysis. The leaves and LPCs present a good source of threonine, lysine, leucine and isoleucine but are limited by methionine and cysteine. Dried and ensiled cassava leaves may find value as fodder for ruminants while LPCs are better suited for human dietary supplementation. This study presents the opportunity to produce a valuable product from cassava leaves, which are currently designated as post-harvest waste.*

Keywords*: Cassava leaves, leaf protein concentrates, amino acids, plant protein*

Authors' Biographical Notes:

Annaleise H.L. Aiken *is associated with the Department of Chemistry, Faculty of Science and Technology, The University of the West Indies, Mona Campus, Jamaica.*

Ian L. Thompson *is associated with the Department of Chemistry, Faculty of Science and Technology, The University of the West Indies, Mona Campus, Jamaica.*

G. Harvey Anderson *is associated with the Department of Nutritional Sciences, Faculty of Medical Sciences, University of Toronto, Canada.*

Diptendu Chatterjee *is associated with the Department of Nutritional Sciences, Faculty of Medical Sciences, University of Toronto, Canada*.

■

The Design and Fabrication of a Function Fertiliser

Robert A. Birch[1], Stefan Thompson[2], and Gaius Eudoxie[3]

[1,2]Department of Mechanical and Manufacturing Engineering, Faculty of Engineering The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies;
[1] Email: Robert.birch@sta.uwi.edu
[2] Email: Stefan_thompson@hotmail.com

[3] Department of Food Production, Faculty of Food and Agriculture, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies; Email Gaius.eudoxie@sta.uwi.edu

Abstract: *Caribbean farmers sometimes deposit granular fertiliser on the soil surface as a method of metering nutrients to crops. Surface placement of granular fertiliser encourages nutrient losses via multiple pathways, while ineffectively targeting plant roots. A device called the function fertiliser was designed and fabricated to deposit granular fertiliser at a suitable depth into the soil and therefore reduce surface placement losses. This paper describes the methodology used in designing and developing the second iteration of the function fertiliser. The design process used a combination of quality function deployment (QFD) and computer aided engineering (CAE) in realising a final design that was reasonably price, a single user applicator, lightweight and simple to use, thus making it affordable and appropriate for small scale farmers of the Caribbean. Field performance results showed that the function fertiliser achieved a minimum deposit depth of 48 mm while the measured peak and average field efficiencies were 63.45% and 42.62% respectively. The use of the function fertiliser would improve fertiliser use efficiency, whilst reducing environmental risk. Further, the improved efficiency should realise greater productivity at lower operational costs and an overall higher profit margin for farmers.*

Keywords*: Function fertiliser, Design, Computer Aided Engineering*

1. Introduction

Caribbean farmers sometimes deposit granular fertiliser on the soil's surface as a method of metering nutrients to crops. This is an ineffective way of applying fertiliser as it allows nutrient losses via multiple pathways and ineffectively targets the roots of the plants. One approach is to use liquid fertiliser applicators. These devices deposit liquid fertiliser which is quickly absorbed by plants and are therefore better than the solid applicators (Xi et al. 2011). However, most liquid fertiliser applicators use some sort of pumping and metering mechanisms and are thus, powered and drawn by the tractors (Kamal 2008) or self-propelled (Chunfeng et al. 2015) making them applicable for large agricultural fields.

Hence, during 2016, at the University of the West Indies a portable solid fertiliser applicator device was designed and fabricated to meter and deposit granular fertiliser at a certain depth under the surface of the soil. This device, which is called the function fertiliser was our solution to the problems faced by the farmers of small land holdings. The device was designed to be carried by one individual over the difficult terrains that exist in many farms of the Caribbean.

Field performance test on the first design iteration showed that the fertiliser was deposited at depths of 39 mm below the soil surface and the field efficiency of the operation was 31.5%. The device had major faults, which included the weight of the device being too high thus making it very heavy to carry and difficult to move through the fields. Secondly the device was void of suitable ergonomic considerations making it cumbersome and very difficult to operate. Thirdly, the device was ineffective in moist soils as it was susceptible to clogging during operation which further decreased its efficiency.

Marini and Romano (2009) identified that the use of a systematic and structured framework in the design phase was an effective approach in improving a design. The PDD process is a known structured framework for the design phase and uses multiple sources of information through product and market research, that effectively blends the data acquired from existing products with that of the customer needs. This information is an input into the quality function deployment (QFD) table and is a significant stage in the PDD process. Customer needs are aligned with design parameters resulting in the development of design specifications. These final design specifications are then used to generate design concepts using computer aided design (CAD). The CAD environment is significant as it assist engineers in the creation, optimisation, analysis and modification of the design product. For instance, Hermawan (2017) successfully developed concept designs of a fertiliser applicator for palm oil using a comprehensive structured approach and computer aided design (CAD) while Kamboj et al. (2012) used CAD in

designing a pea depoding machine. Deraniyageda (2001) has stated that the use of CAD in the design of agricultural machinery in developing countries was a form of complex incremental technical change that leads to improvement of the core technology, but the use of CAD is part of the process. The use of simulations allows us to fully access the virtual environment and perform test on the design components without having to fabricate the component. This reduces time and cost as there is a reduction in repeated analysis and prototype building (Kamboj et al. 2012). The addition of the simulation component changes the computer aided design (CAD) to computer aided engineering (CAE). The combination of PDD and CAE allows for the improve development of the functional function fertiliser. There exists very little literature on the combined use of PDD and CAE in improving the design and development of agricultural machinery. This paper, therefore, discusses a methodology used in applying PDD and CAE to obtain an improved second iteration of the function fertiliser.

2. Design Methodology

The PDD is an iterative process that is used to optimise the design process (Magrab et al. 2009). A modified version of the PDD process and CAE was employed (see Figure 1) to effectively improve the design of the function fertiliser. One of the major challenges was the lack of existing function fetilisers. This created a hindrance in the application of the PDD process as there was no way of optimising the design through the standard iterative process. Hence our PDD process was modified with the following considerations

i. Emphasis was placed on component function structure
ii. The design requirements were critically analysed
iii. The process of benchmarking was reorganised to take account of the lack of existing products
iv. The QFD was modified through the addition of the design concepts as part of the matrix. This was further ranked and weighted.

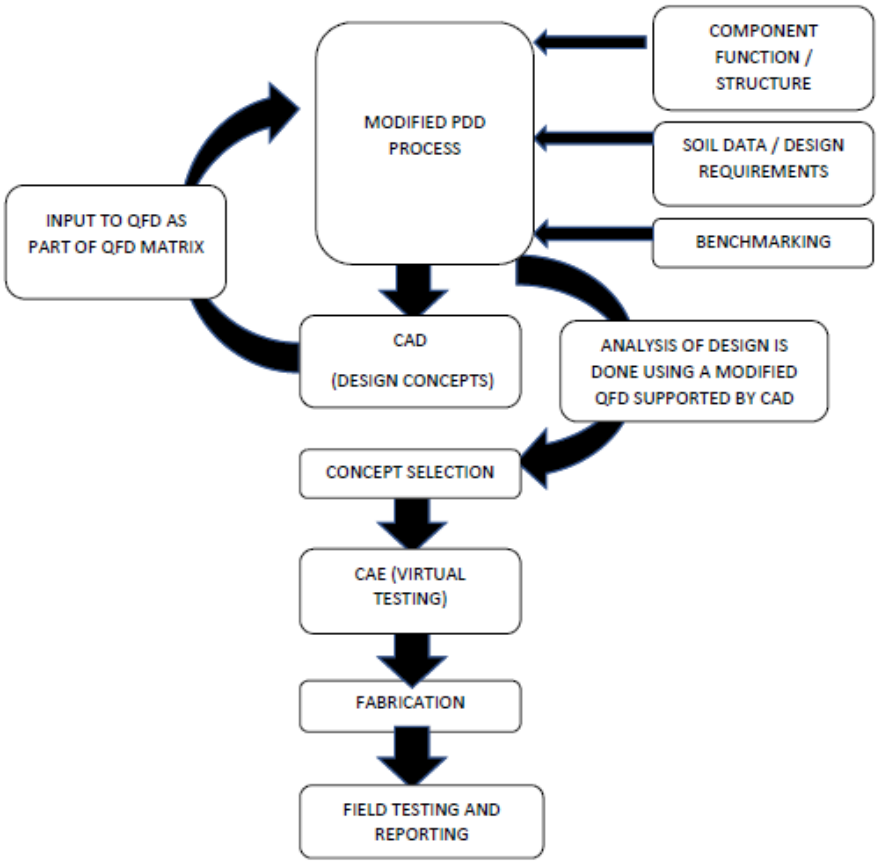


Figure 1: Process involved in the Design, Fabrication and Field Testing of Function Fertiliser incorporating a modified PDD process and CAE

Our PDD process when executed performed firstly, a comprehensive research analysis. This involved the use of the function structure where the function fertiliser was decomposed into three subsystems which were soil surface penetration, metering and soil covering. The use of the function structure reduces the uncertainty in the design process (Marini and Romano 2007). A full review of the previous design was done where the process involved detailing the function of each part and determining weakness and strength which were tabulated. This information formed inputs to the QFD.

Secondly the design requirements were developed by considering the soil as an engineering material. We investigated the physical characteristics of the soil in which the device would operate. The research into the physical behaviour of Trinidad soils showed that the tool penetration into soil is affected by soil type, water content and compaction of the soil (Birch et al. 2016). The average peak penetration resistance of the six different soils in Trinidad is 5.71MPa (Eudoxie et al. 2012). This value was used to determine the minimum force required for the function fertiliser to penetrate the soil. The workability of soils can be further understood from the Atterberg limit as it shows the soils ability to withstand deformation at various moisture contents (Roopnarine et al. 2012). Soil fails when the applied shear force exceeds the shear strength of the soil (Birch 2018; Koolen and Kuipers 1983). Thirty soils from Trinidad were investigated by Roopnarine et al. (2012), the results of this investigation gave a good representation of the behaviour of soils in Trinidad. The investigations showed that the mean shear strength value for soils was 49.7 kNm^{-2} and the internal friction angle (α) ranged from 11.7° to 43.5°. To find the tool penetration angle (θ) that resulted in shearing, the inclination of the failure plane was considered using Mohr Coulomb failure criteria. Hence the angle (θ) was calculated to be = 1⁄2 (90° + α) (Koolen and Kuipers 1983) and the inclination angles for Trinidad soils therefore varied between 50.82° to 66.75°. This information was useful in designing the blade maximum penetration strength and penetration angles for the function fertiliser.

A full market research was performed with farmers to determine their needs when using this type of device. An investigation into product research determined that the tools available for fertiliser application used broadcasting as the delivery method. This method is deemed ineffective since it poses the same problems as hand dispersion. The PDD process continued with product design specification. In this stage the needs of the farmers were tabulated, interpreted and a weighting was given to each need. Thereafter, the comprehensive list of metrics and the customer needs matrix were created. Since the current products used broadcasting as the method of operation, competitive benchmarking became difficult and we resorted to using the first iteration as the bench mark. The creation of the competitive benchmarking chart was done after the concepts were created. The design concepts were generated using a combination of the blackbox method and a functional decomposition. This was used to assess the operation of the device as it related to plant root fertilisation. Further development included the use of a classification tree to generate concepts for the soil penetration component of the device. Together, these three methods created the ideal blend for generating multiple concepts.

The concepts were then created in the virtual environment using a CAD software called SolidWorks. The SolidWorks allowed the creation of 3D models of the concepts. These shape and geometry of the concepts were easily adjusted in the virtual environment. The created concepts were weighed and benchmarked against the first iteration of the function fertiliser. The competitive benchmarking was done based on the perceived satisfaction of the farmer's needs. The three concepts were analysed and compared to that of the first iteration of the function fertiliser. The typical method of hand dispersion of the fertiliser and its flaws were also included. All the information was included into the QFD to generate the most completed results. The designs were then put through a concept selection criterion and rated against the first prototype. This filtered the designs and left two designs. Relative weightings were placed on the farmer's needs and this gave the final design. This was used to determine target specifications which were then refined to final specifications. The QFD was an integral part of the design process. It was specially modified to accommodate the introduction of the concepts as part of the matrix and realised the final concept through a weighted selection process. Failure Modes and Effect Analysis (FMEA) was performed on the selected concept to determine the adequate materials and permitted additional optimisation to the device.

A detailed design was generated using CAD while considering the final specifications. This led to the final design (see Figure 2) in which calculations were done to determine material selection and sising for the device.

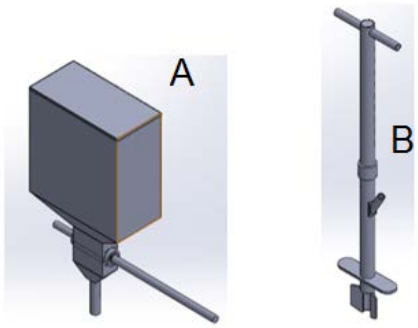


Figure 2: Final Design of Canister (A) and Pole Assembly (B) for Function Fertiliser.

The final design which was then drawn in SolidWorks underwent buckling simulations. This transformed the CAD process into CAE and allowed us to perform virtual test on the final design (Figure 3) before fabrication. Because of the method of operation of the function fertiliser it was only necessary to perform buckling tests on the tool. Once these test were successful, the engineering drawings for the final design were produced and approved. The device was then fabricated and field tested.

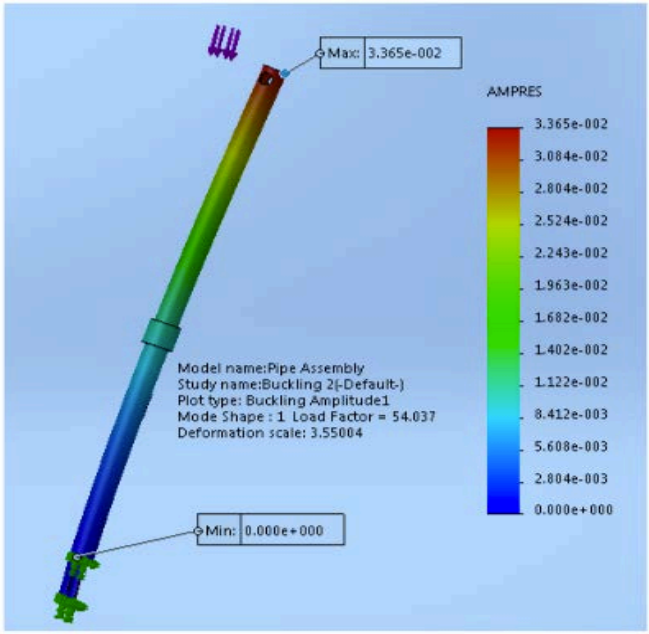


Figure 3: CAE using SolidWorks. A buckling simulation for the pipe assembly of Function Fertiliser.

Field tests on the device were performed at six (6) farm locations in Trinidad. All experiments were repeated. The experiments included testing for maximum depth of granular deposit and field efficiency of the device. Test on shear strength and water content of the soils were also performed. At each location 40 plants were randomly chosen. The device was filled with granular fertiliser and this was deposited near 20 plants. The time taken to deposit the fertiliser and the walk times were recorded. Measurements on the depth of deposit and area of penetration were taken using a measured rule and Vernier caliper. At the site, six different areas were chosen where a shear vane was used to measure the shear strength of the soil. Soil was then collected and placed into a labeled Ziploc bag. The contents were used to measure the water content of the soil. Water was then added to the soil the device was again filled with granular fertiliser and deposited near another 20 plants. Measurements were again taken on maximum depth of deposit and walk times as well as shear strength and water content.

3. Discussion and Results

3.1 SolidWorks Results

There were limited materials available for the design and fabrication of the function fertiliser. The manual calculations yielded a maximum force of 820N and this was used in SolidWorks to perform buckling tests yielding a Factor of Safety of 54. Though it was an overdesign it confirmed that the available material was suitable for use.

3.2 Results of field tests.

The final design of Function Fertiliser consisted of a backpack canister and a pole assembly as shown in Figure 4. The backpack canister was lightweight but sturdy and contained a maximum of 8 kg of the granular fertiliser. The pole assembly consisted of two handles, a mash bar, an insert or short hollow tube above the mash bar and a blade at the bottom of the pole assembly. The device penetrates, shears the soil, meter the fertiliser and deposits the fertiliser into the soil. The boot of the farmer is used to cover the soil afterwards. The pole assembly is held by the hands very easily at the handles and is inserted at an angle into the soil and rotated to remove some of the soil. The fertiliser is then metered into the soils from the canister through the pole assembly via the hollow tube insert (Figure 4). The fertiliser is metered using fluted rollers. Fluted rollers are typically used for metering granular products since the groves allow for continuous rotations and dispersions (Cuplin 2014). The rollers deposited a mass of 4 g and 10 g with crank rotations of 30 and 60 degrees, respectively.

The function fertiliser was tested at six locations in Trinidad and deposited granular fertiliser at average minimum depth of 48 mm below the soil surface. This exceeded the required depth of 39 mm. Studies conducted by Ekwue et al. (2010) on three Trinidadian soil types resulted in an average depth of wash erosion of 18 mm for relatively low sloping lands and an average wash erosion depth of 39 mm for increased gradients consistent with the maximum runoff with an increased gradient for Trinidad (Ekwue et al. 2010).

In Table 1, the average field efficiency of 42.62% was an 11.08% increase over the previous iteration. This average value is lower but close to that of the field efficiency of Hand Dispersion techniques which is 50%. The measured peak value of field efficiency was 63.45% and was a closer representation to the function fertiliser's true efficiency since these tests were performed during the dry season in Trinidad. The soil at this instance was harder and more compacted and therefore a more difficult to penetrate. The first average moisture content reading on the field test (dry basis) for the soils had a peak value of 10.09% while in Rickey Tr. the minimum moisture content was observed to be 1.68% (dry basis).

Figure 4: Photograph of final design being field tested

Table 1 Results of Field Efficiency and Field Capacity test

	SIMULATION 1		SIMULATION 2	
AREA	FIELD EFFICIENCY n_f (%)	FIELD CAPACITY C_a (ha/hr)	FIELD EFFICIENCY n_f (%)	FIELD CAPACITY C_a (ha/hr)
LAS LOMAS A	63.45	0.0077	48.92	0.0089
LAS LOMAS B	52.35	0.0087	42.05	0.0080
SMITH'S FIELD WALLERFIELD	47.72	0.0068	33.39	0.0056
CUMUTO	36.56	0.0066	38.49	0.0071
RAVINE SABLE	38.37	0.0079	40.43	0.0064
RICKEY TRACE (SAND PIT)	32.55	0.0071	37.12	0.0075
AVERAGE	45.17	0.0075	40.07	0.0073
AVERAGE nF (%)	42.62			
AVERAGE Ca (ha/hr)	0.0074			

These values illustrated that the soil was well below that of the friable limit. Thus the function fertiliser achieved these efficiencies in a difficult environment. In Las Lomas (A), when using the shear vane the shear strength of the soil for one area resulted in a maximum value of 126 kPa while in another test area about 10 m apart, a maximum shear strength value of 55 kPa was observed. This was half the value of the first area and may be interpreted that the test locations had a drastic variation in soil compaction levels as compaction levels affects both bulk density and shear strength of the soils. However, the device was designed with a high factor of safety and was able to penetrate the soils surface and effectively meter and deposit the granular fertiliser.

This design has shown improvements over the first iteration because it is less heavy and much easier to carry. The handles provide ease of holding the device and the canister holds sufficient fertiliser. The first iteration operated with the soil being punctured to create an area to deposit the fertiliser this caused compaction and therefore reduced the tool's penetration effectiveness as penetration depth increased. Additionally, the flap of the first iteration prevented soil from entering into the fertiliser but encouraged clogging. These two reasons led to the creation of the blade design which operated by shearing the soil. Because of the slender design of the blade, the function fertiliser was able to optimise its penetration force and displaced the soil to create the required orifice during soil penetration. The use of the product development and design techniques outlined allowed for an effective ergonomically designed function fertiliser.

4. Conclusion

The design and fabrication of the second iteration was an improvement over the first iteration. The use of the PPD process combined with the CAE provided the necessary foundation for the development of a functional design that met the needs of the farmers. The device operated well. It penetrated and sheared the soil, metered the fertiliser and the boot of the farmer was used to cover the soil afterwards. Future work would involve a more light weight and ergonomic design as well as incorporating a metering device closer to the base of the pole to allow faster deposit of the granular fertiliser.

References:

Birch, R.A. (2018), *The Characterisation of Tensile Fracture and Crack Propagation in Trinidad Soils with Varying Peat Content with Applications in Tillage*, PhD Thesis (unpublished), The University of the West Indies, St. Augustine, Trinidad and Tobago.

Birch, R.A., Ekwue, E.I, and Phillip, C.J. (2016), "Soil-metal sliding resistance forces of some Trinidadian soils at high water contents." *West Indian Journal of Engineering*, Vol.38, No.2, pp.52-58.

Culpin, C. (2014), *Farm Machinery*, 12 Edition. Wiley, New York

Deraniyagela, S. (2001), "The impact of technology accumulation on technical efficiency: An analysis of the Sri-Lankan clothing and agricultural machinery industries", *Oxford Development Studies*, Vol.29, No.1, pp.101-114.

Ekwue, E.I., and Harilal. A. (2010), "Effect of soil type, peat, slope, compaction effort and raindrop erosion of some Trinidadian soils", *Biosystems Engineering*, Vol.105, No.1, pp.112-118.

Eudoxie, G.D., Phillip, D. and Springer, R. (2012), "Surface hardness as an indicator of soil strength of agricultural soils", *Open Journal of Soil Science*, Vol.2, No.4, pp.334-346

Hermanwan, W. (2018), "Conceptual Design of fertiliser Applicator for Oil Palm on Terrace Cultivation." In: *Agricultural Engineering for Sustainable Agricultural Production (ASEAP 2017)*, IOP series: Earth and Environmental Science, Vol.147, pp. 1-13

Kamal, K. (2008), *Studies on Design Parameters of Aqueous Fertiliser Placement with Seed Drill*, PhD Thesis (unpublished), Indian Agricultural Research Institute, New Delhi.

Kamboj, P., Singh, A., Kumar, M. and Din, S. (2012), "Design and development of small scale pea depoding machine by using CAD software", *Agricultural Engineering International: CIGR Journal*, Vol.14, No.2, pp.40-48

Koolen, A.J., and Kuipers. H. (1983), *Agricultural Soil Mechanic*. Springer-Verlag, New York

Magrab, E.B., Gupta, S.K., McCluskey, F.P., and Saniborn, P.A. (2009), *Integrated Product and Process Design Development: The Product Realisation Process*, 2nd Edition, CRC Press, Boca Raton

Marini, V.K., and Romano, L.N. (2007), "The function structure as a tool for analysing an existing concept of a centrifugal fertiliser spreader", *Product: Management and Development, Brazilian Journal of Product Development Management*, Vol.5, No.2, pp.77-89

Marini, V.K., and Romano, L.N. (2009), "Influencing factors in agricultural machinery design", *Product: Management and Development, Brazilian Journal of Product Development Management*, Vol.7, No.2, pp.111-130

Roopnarine, R., Eudoxie, G., and Gay, D. (2012), "Soil physical properties as predictors of soil strength indices: Trinidad case study", *Geomaterials*, Vol.2, No.1, pp. 1-9

Xi, X., Wang, J., and Lang, C. (2011), "Module design for parameter optimisation of pricking hoe: Mechanism of deep-fertilisation, liquid fertiliser application", *Proceedings of the 2011 IEEE International Conference on Computer Distributed Control and intelligent Environmental Monitoring*, Changsha, China, 19-20 February, pp.480-482.

Zhang, C., Li, J., Wang Xiu, W., and Shuai, S. (2015), "Development and experiments on the injection system of the self-propelled liquid fertiliser machine", *Proceedings of the 5th Annual IEEE International Conference on Cyber Technology in Automation, Control and Intelligent Systems*, Shenyang, China, 8-12 June, pp.1650-1654.

Authors' Biographical Notes:

Robert A. Birch *is an Instructor with the Department of Mechanical and Manufacturing Engineering at The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies. He has a BSc and MPhil in Agricultural Engineering and is currently a PhD candidate in Mechanical Engineering. Mr. Birch is a professional engineer (R.Eng) with more than 23 years industry experience and a member of the Institute of Agricultural Engineers, U K (MIAgrE). His research interests are in the design and development of machinery systems and Computer Aided Engineering (CAE).*

Stefan Thompson *is a final-year student pursuing a BSc. in Mechanical Engineering with the Department of Mechanical and Manufacturing Engineering, Faculty of Engineering at The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies. He has a diploma in Motor Vehicle Engineering and also owns and operates an organic farm.*

Gaius Eudoxie *is a Lecturer in the Department of Food Production, Faculty of Food and Agriculture, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies.*

■

Focusing on Interactions between Individuals and Their Learning Environment: A New Step Forward for Science Education

Alexandra Renouard[1] and Yves Mazabraud[2]

[1] Université de Strasbourg, CNRS, IPGS, UMR7516, France; Email: renouard@unistra.fr;

[2] Université des Antilles, UMR5243 Géosciences Montpellier, Guadeloupe, France; Email: yves.mazabraud@univ-antilles.fr

Abstract: *The scientific literacy level of the whole population has long been focusing the attention of researchers because of its direct impact on many aspects of our lives. The very recent disaster of Palu, Indonesia, where the population suffered a M=7.5 earthquake and a deadly tsunami on September 28 2018 is a dramatic example. Indeed, despite the fact that the time between the earthquake and the costal wave arrival was sufficient to warn and partially evacuate people at risk, the crisis was paradoxically not ideally dealt with, resulting in multiple casualties due to the tsunami. This surprising unsafely behaviour highlights a poor preparation of the population, but also of the local authorities. However, since the 2004 Sumatra's catastrophe, educational efforts and the development of a tsunami early-warning system have taken place. On the same day, but in the Caribbean, another seismic event, of M=6.3, occurred South-East of Dominica. Although it did not caused notable damage, it was largely felt in Martinique, Dominica and Guadeloupe. This earthquake has also triggered a small tsunami along the eastern coast of Dominica. The wave, which was only a few centimeters high, did no cause casualties. But, against all odds, the local population, despite having felt the earthquake, stayed by the sea and watched the sea rising without taking any measure of protection, such as reaching high ground. It was as if they were unaware of the scope of the phenomenon. So, how can we explain such universal unsafely behaviours? How can we explain this weak anchoring of the risk culture in a population, and especially in the Caribbean, while educational efforts are being conducted and many studies have been engaged?*

This educational paradox has inspired many studies in cognition, motivated by such educational issues. As a matter of fact, they have allowed identifying many misconceptions of scientific ideas. Most of which are often based on irrational beliefs, old theories, unscientific reasoning, or unassimilated conceptual instruction. As a result, individual conceptions are now accurately described in many scientific fields, such as geosciences for example, which has led to improvements in science teaching and learning. Nevertheless, the community (scientists, academics, high school and primary school teachers, educators) has not yet succeeded in solving all the issues. Some pre-existing misconceptions still persist in the population and impede a solid risk culture. This constitutes a strong obstacle to the efficiency of risk-management policies. That's why we argue that cognition studies must now focus on the origin of individuals' conceptions and on their modes of acquisition and propagation in order to provide educational tools for acting upstream during their very acquisition. We also present a model (symbolically based on the crystalline structure of silicate minerals) that represents and describes the educational context of each individual. The characterization of individual contexts then offers the possibility to design targeted actions for the acquisition of scientific conceptions, following the methodology described in Renouard and Mazabraud (2018).

Keywords*: Alternative conceptions, inhibitory brain processes, cognition studies, learning context*

References:

Renouard, A. and Mazabraud Y. (2018), "Context-based learning for Inhibition of alternative conceptions: the next step forward in science education", *Nature partner journal Science of Learning*, Vol.3, No.10. doi 10.1038/s41539-018-0026-9

Authors' Biographical Notes:

Alexandra Renouard *is currently a PhD student in seismology at the Institut de Physique du Globe de Strasbourg. She has over a decade of experience of teaching in several High-schools and universities in France, Spain and in the Caribbean. Her background includes biological sciences, geosciences and science education. Her work focuses on both intraplate and plate-boundary seismicity as well as science education.*

Yves Mazabraud *is a geophysicist specialized in crustal deformation. His work focuses on the precise description of the earth's deformation patterns in order to emphasize the mechanisms at the origin of stress concentrations, using a variety of tools such as seismology, geodesy, field geology and tectonics. He also developed an expertise in geocognition and the study of geosciences related conceptions of students. He is an Assistant Professor at the Université des Antilles (Guadeloupe).*

■

Coffee Crop Phenology and Infestation by the Coffee Berry Borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae) in the Highlands and Blue Mountains of Jamaica

Ameka N. Myrie[1] and Dwight E. Robinson[2]

Department of Life Sciences, Faculty of Science and Technology, The University of the West Indies, Mona, Jamaica;
[1]Email: mekamyrie@yahoo.com;
[2] Email: Dwight.Robinson@uwimona.edu.jm;

Abstract: *The Coffee Berry Borer (CBB), Hypothenemus hampei (Ferrari), is of great importance within Coffee Industries worldwide as crop losses due to this pest range from 5 to 25 percent. The worldwide economic loss is approximately 500 million USD from a 173 billion US dollar industry. In Jamaica, the Coffee industry loses approximately 30 million JMD annually. With drastic infestation, there may be losses of 50% or even higher for places such as Jamaica where the floating method is used in processing. The assessment of the relationship between coffee crop phenology and percentage infestation is relevant, as it permits an assessment of variations in percentage infestation throughout the year based on specific crop phenology. This information is able to form the baseline for the creation and implementation of strategies that may assist in the management of the pest. There are six stages to Coffee Phenology in Jamaica, the first stage being the Dogteeth stage and the final stage being the Mature Ripe Berry stage, which is typically the time of harvest. The coffee phenology profile in Jamaica is determined by the microclimate of the area in which the crop is grown, thus the phenology of coffee in Jamaica varies at the Blue Mountain and Highland levels within the country. In order to assess possible relationships between crop phenology and CBB infestation, data was gathered on the percentage infestation of coffee berries on plants at different phenological stages in the Blue Mountains and Highlands of Jamaica over a fourteen and thirteen month period, respectively. One flowering period was observed in the Highland site while two flowering periods were observed in the Blue Mountain site. The highest mean percentage infestation was observed when the crop was at the pimento sized berries (56.0 ±29.4%) and flowering (18.0% ±7.0%) phenological stages in the Highlands and the Blue Mountains, respectively. The CBB infestation was higher in the Highlands (18.8% ±1.6%) compared to the Blue Mountains (13.3 ± 1.5 %) of Jamaica. The data indicates a distinct difference in the phenology of the coffee crop in the Blue Mountains and Highlands of Jamaica and this is influencing the infestation pattern and possibly damage caused by the CBB.*

Keywords*: Crop Phenology; Coffee industry; Jamaica*

Authors' Biographical Notes:

Ameka N. Myrie *is assocaited with the Department of Life Sciences, Faculty of Science and Technology, The University of the West Indies, Mona, Jamaica.*

Dwight E. Robinson *is assocaited with the Department of Life Sciences, Faculty of Science and Technology, The University of the West Indies, Mona, Jamaica.*

■

Response Analysis of Fuzzy Fractionally Damped Mechanical Spring-Mass System

Diptiranjan Behera

Department of Mathematics, The University of the West Indies, Mona Campus, Kingston 7, Jamaica, West Indies;
Emails: diptiranjan.behera@uwimona.edu.jm; diptiranjanb@gmail.com

Abstract: *This paper investigates the uncertain response of imprecisely defined fractionally damped dynamic system, subjected to a unit step load. In this regard, a fractionally damped mechanical spring-mass system of order 1/2 with fuzzy initial condition has been taken into consideration. Fuzziness appeared in the initial conditions are modelled through triangular convex normalised fuzzy sets. Here double parametric form of fuzzy number has been used along with Adomain Decomposition Method (ADM) to obtain the solution. Obtained uncertain series solution has been expressed in general form. Different case studies have been made and obtained results are compared in special cases to show the efficacy of the proposed analysis.*

Keywords*: Fuzzy number, spring-mass system, fractional damping, ADM*

Author's Biographical Notes:

Diptiranjan Behera *is currently working as a Lecturer at the Department of Mathematics, The University of the West Indies, Mona Campus, Jamaica. Before that he has worked as a Postdoctoral Research Fellow at Center for System Reliability and Safety, University of Electronic Science and Technology of China, China from March, 2015 to April, 2018. Dr. Behera has completed his Ph. D. degree from the Department of Mathematics, National Institute of Technology Rourkela, Odisha, India in January, 2015. His research interest includes in the areas of Structural analysis, Differential and fractiaonal differential equations, Numerical methods, Optimisation problem and Fuzzy set theory.*

■

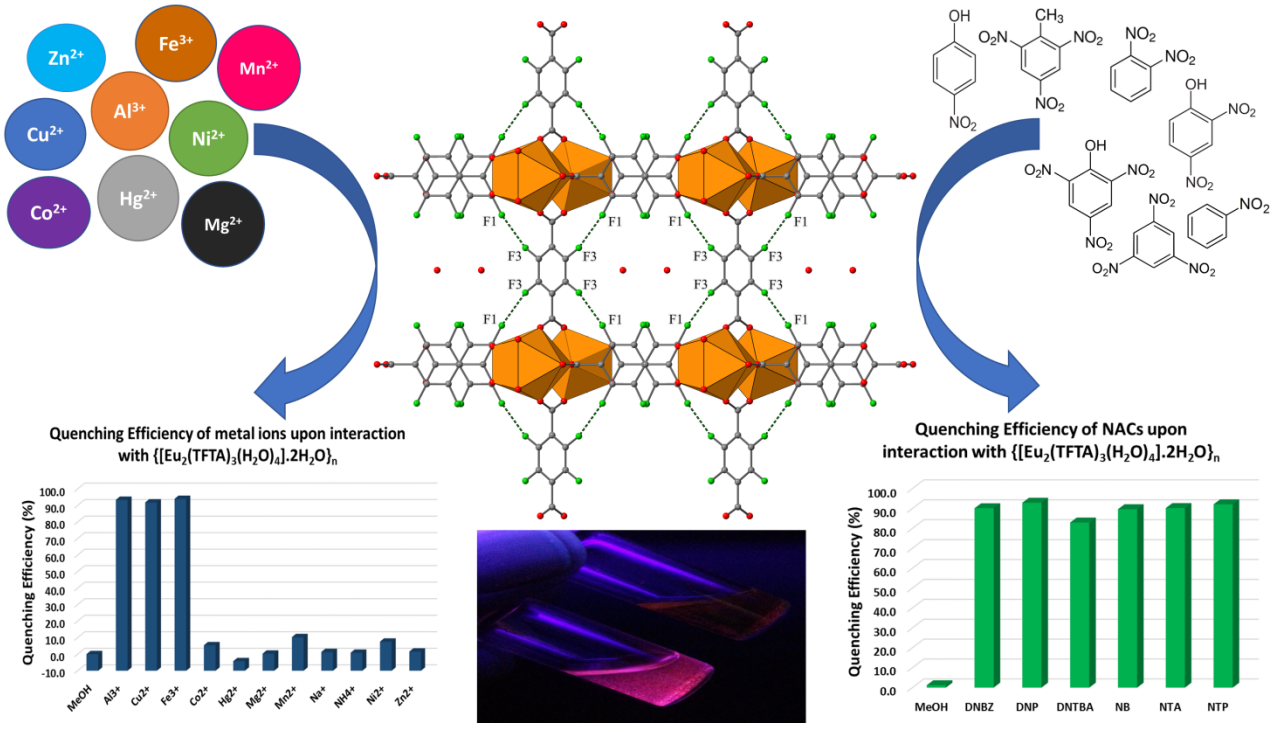
New Rare-Earth Metal-Organic Frameworks from Perhalogenated Terephthalate Ligands: Fluorescence Sensors for Iron, Copper and Nitroaromatic Explosives

Jermaine A. Smith[1], Marvadeen A. Singh-Wilmot[2], Korey P. Carter[3], Christopher L. Cahill[4] and James A. Ridenour[5]

[1,2] Department of Chemistry, The University of the West Indies, Mona, Kingston 7, Jamaica, West Indies.
[1]Email: jermaine.smith02@mymona.uwi.edu;
[2]Email: marvadeen.singhwilmot@uwimona.edu.jm;

[3,4,5] Department of Chemistry, The George Washington University, Washington D.C., USA.
[3]Email: korey.p.carter@gmail.com;
[4]Email: cahill@gwu.edu;
[5]Email: jaridenour@gwmail.gwu.edu

Abstract: *Metal-Organic Frameworks (MOFs) are a new class of porous coordination polymers (CPs) with well-defined topologies that continue to intrigue scientists not only because of their appealing structural architectures, but also because of their potential applications in gas storage and separation, sensing of small molecules, catalysis and biomedicine (Cui, et al., 2012). The synthesis of MOFs using rare earth (RE) ions is still relatively under explored when compared to transition metal-based systems, due to their unpredictable coordination chemistry. There are however significant advantages to be gained by combining the unique catalytic, magnetic and light emitting properties of RE ions with the properties of CPs and MOFs (Singh-Wilmot et al., 2017; Smith et al., 2016; Min et al., 2012). By reacting rare-earth ions with tetrafluoro- and tetrabromo-terephthalate ligands under slow evaporation conditions, we have been able to create 28 novel rare-earth CPs and MOFs having interesting structural features and promising luminescence sensing properties. We demonstrate the potential of these compounds as fluorescence sensors for Fe^{3+}, Cu^{2+} and explosive nitro-aromatic compounds (NACs) such as 4-nitro-, 2,4-dinitro- and 2,4,6-trinitro-phenol.*



Keywords*: Rare Earths, Metal-Organic Framework, Coordination Polymer, Fluorescence Sensing, Nitro-aromatic Explosives*

References:

Cui, Y., Yue, Y., Qian, G., and Chen, B. (2012), "Luminescent functional metal-organic frameworks", *Chemical Reviews*, Vol.112, No.2, pp.1126-1162.

Singh-Wilmot, M. A., Sinclair, R. A., Kahwa, I. A., and Lough, A. J. (2017), "Eu^{3+} substitutional defects and their effect on the luminescence spectral and decay dynamics of sal-type one dimensional rare earth coordination polymers and trinuclear complexes", *Journal of Luminescence*, Vol.182, pp.98-106.

Smith, J. A., Singh-Wilmot, M. A., Carter, K.P., Cahill, C.L., Lough, A.J., and Knee, C.S. (2016), "Eight rare earth metal organic frameworks and coordination polymers from 2-nitroterephthlate: syntheses, structures, solid-state luminescence and an unprecedented topology", *New Journal of Chemistry*, Vol.40, No.9, pp.7338-7349.

Min, Z., Singh-Wilmot, M.A., Cahill, C.L., Andrews, M., and Taylor, R. (2012), "Isoreticular lanthanide metal-organic frameworks: Syntheses, structures and photoluminescence of a family of 3D phenylcarboxylates", *European Journal of Inorganic Chemistry*, Vol.28, pp.4419-4426.

Authors' Biographical Notes:

Jermaine A. Smith *is a Ph.D. candidate under the supervision of Dr. Marvadeen Singh-Wilmot in the Chemistry Department of The University of the West Indies, Mona. His research focuses on the synthesis, characterisation and potential applications of novel rare-earth metal-organic hybrid materials. He has one publication in a peer-reviewed journal and has made presentations of his research at local and international conferences.*

Marvadeen A. Singh-Wilmot *is a lecturer in Inorganic Chemistry at the University of the West Indies, Mona. Her research expertise includes rare-earth chemistry, hybrid materials, X-ray crystallography and photo-electronic characteristics of luminescent materials. She has authored numerous articles as well as a book titled 'Dipicolinic Acid, its Analogues and Derivatives; Aspects of their Coordination Chemistry'. Dr. Singh-Wilmot has a passion for science and has been recognized for her outstanding research having been awarded the best research publication award in 2014 and 2018 at the UWI Principal's Research Awards. She is also the first Caribbean national to be inducted as a Young Affiliate Fellow of The World Academy of Sciences (TWAS) and is currently a member of The Young Affiliate Network (TYAN).*

Korey P. Carter *is a Ph.D. graduate (2017) from the George Washington University who currently works at Lawrence Berkeley National Laboratory where he does research in Inorganic, Materials, and Physical Chemistry focused on d- and f-block complexes. He has expertise in actinide and lanthanide chemistry, X-ray crystallography, and vibrational and luminescence spectroscopy. To date he has published twenty-nine research items which include a book chapter titled "Hybrid Materials of the f-Elements Part I" in Handbook on the Physics and Chemistry of Rare Earths and twenty-eight articles in peer reviewed journals.*

Christopher L. Cahill *is a Professor of Chemistry and International Affairs at the George Washington University. His area of expertise spans hybrid materials, f-element chemistry, nuclear fuel cycle, X-ray crystallography, and luminescent materials. He has published in over 130 peer reviewed journals and successfully supervised thirteen Ph.D. graduates. A major focus of his research group is the X-ray structural characterisation of large families of both novel and naturally occurring solid-state compounds to establish assembly criteria and structure-property relationships, with a particular emphasis on luminescence behaviour.*

James A. Ridenour *is a Ph.D. candidate under the supervision of Professor Christopher Cahill in the Chemistry Department of the George Washington University. His research involves the fundamental exploration and assembly of f-elements bearing hybrid materials utilising supramolecular interactions, structural characterisation of novel materials via single crystal X-ray diffraction, and the study of spectroscopic structure-property relationships and relevant signatures.*

■

Applications of the Lagrangian Method to Heun Function

Davide Batic[1], Omar A. Forrest[2], and Marek Nowakowskic[3]

[1]Department of Mathematics, Khalifa University of Science and Technology, Main Campus, Abu Dhabi, United Arab Emirates; Email: dbatic@pi.ac.ae;

[2]Department of Mathematics, University of the West Indies, Mona, Kingston, Jamaica, West Indies; Emails: omar_forrest@yahoo.com; omar.forrest02@uwimona.edu.jm

[3]Department of Physics, Universidad de los Andes, Bogota, Colombia, South America; Email: mnowakos@uniandes.edu.co;

Abstract: *Heun's differential equation (HE), constructed by the German mathematician Karl Heun (1889) as a generalisation of the hypergeometric equation, has several applications in Physics, Chemistry and engineering. The textbook Table of Integrals, Series and Products by I.S. Gradshteyn and I.M. Ryzhik devoted several pages to integrals involving the hypergeometric function which can be generalised by an indefinite integral involving Heun functions. Also, indefinite integrals involving Heun functions are useful tools that can be used to study some of the properties of Heun's equation and its solutions. However, there is no well-known indefinite integral involving Heun functions. We present indefinite integrals involving Heun functions obtained by means of the Lagrangian formulation of a general homogeneous linear ordinary differential equation. As a by-product we also derive new indefinite integrals involving the Gauss hypergeometric function and elliptic function of the first kind. All integrals we obtained cannot be computed using Maple and Mathematica.*

Keywords*: Special functions, Heun function, indefinite integrals, Lagrangian Method*

Authors' Biographical Notes:

Davide Batic *received the Laurea (B.Sc.+M.Sc.) degree in Physics from University of Trieste in 1998. In the period 1999-2002 he worked as a researcher in the Department of Safety Research at the Helmholts-Zentrum Dresden-Rossendorf, and received the Ph.D. in Mathematics from University of Regensburg (Germany) in 2005. He has served as faculty member in several universities. Batic has years of research experience in the areas of complex differential equations, spectral theory of unbounded operators, mathematical physics, general relativity, and differential geometry. In addition to the experience of teaching graduate courses in the aforementioned research areas, he has published several research papers in highly reputed international journals.*

Omar Forrest *received a B.Sc. in Mathematics in 2014 from The University of the West Indies (UWI), Kingston, Jamaica. He is currently finishing his M.Phil. programme in Mathematics at UWI under the supervision of Dr. Nagarani Ponakala (U.W.I) and Dr. Davide Batic (KUST). His research focus is on the theory of differential equations with particular emphasis on the Heun equation and its confluent forms. One of his major results is the derivation of new indefinite integrals involving Heun functions and their confluent counterparts.*

Marek Nowakowski *received his B.Sc. degree in Physics from the University of Dortmund (Germany) in 1980, followed by a M.Sc. in Physics in 1984 and he finished his Ph.D. in Physics at the University of Dortmund in 1989. He is currently associate professor at the Department of Physics of the Universidad de los Andes in Bogotá, Colombia. Nowakowski has successfully conducted research activity in disparate areas of theoretical and mathematical physics ranging from elementary particle physics to black hole physics, differential geometry of space-times relevant to general relativity and black hole solutions inspired by noncommutative geometry. He published papers in scattering theory in the presence of compact gravitational sources as well as in supersymmetric quantum mechanics, cosmology, and integrable systems. He is, however, best known for his studies regarding the cosmological constant, the W- and Z-boson interactions in supersymmetric models with explicit R-parity violation and the vacuum oscillation in the supersymmetric standard model. At the moment he published a total of 104 papers and he has h-index 22.*

■

Crystal Engineering of Lanthanide Metal-Organic Frameworks (Ln-MOFs) Using Conceptual Tertiary Building Units (TBUs)

Zeyar Min[1], Marvadeen Singh-Wilmot[2], and Richard A. Taylor[3]

[1,3] Department of Chemistry, University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies;
Email: Zeyar.Min@uwimona.edu.jm;
Email: Richard.Taylor@sta.uwi.edu;

[1,2] Department of Chemistry, University of the West Indies, Plymouth Close, Mona, Jamaica, West Indies;
Email: Marvadeen.SinghWilmot@uwimona.edu.jm

Abstract: *The formation of Metal-Organic Frameworks (MOFs) is governed by molecular recognition and self-assembly processes that are difficult to control. The ability to rationally design and synthesise MOFs for specific applications is significant. However, crystal engineering of Lanthanide Metal-Organic Frameworks (Ln-MOFs) is widely considered to be impossible due to their unpredictable coordination chemistry.[1] To exploit the unique catalytic, magnetic and electronic properties of lanthanides, critical design parameters must be established to advance the crystal engineering of Ln-MOFs. A series of isoreticular Ln-MOFs with 1,4- benzenedicarboxylate (**bdc**), 2,6-naphthalenedicarboxylate (**ndc**), 2,2'-bipyridine-4,4'-dicarboxylate (**bpydc**) and 4,4'-biphenyldicarboxylate (**bpdc**) were judiciously designed and synthesised by extracting design parameters which were critical in implementing a novel synthetic approach using Tertiary Building Units (TBUs) (see Figure 1). This series is the first of only three isoreticular Ln-MOFs reported so far in the literature[3-4] and this approach could alter the general perception on the rational synthesis of Ln-MOFs.*

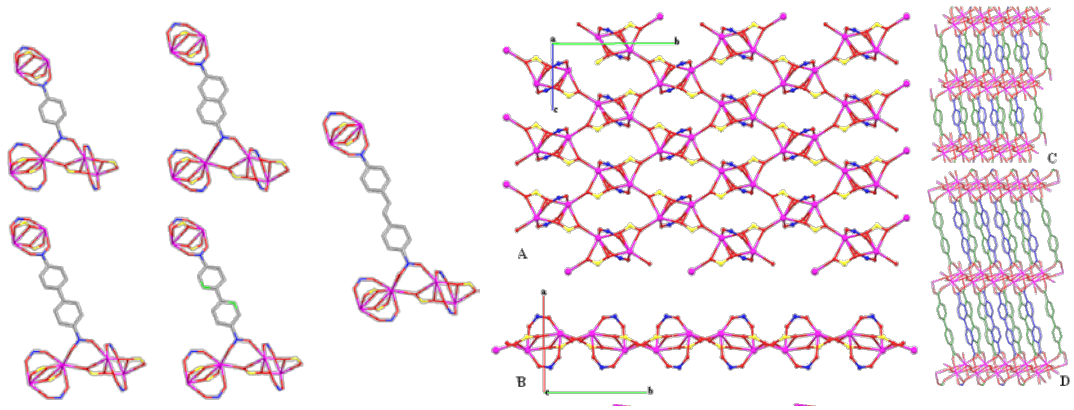


Figure 1 – Five members of rationally designed Lanthanide Metal-Organic Frameworks

Keywords*: Metal-Organic Framework, Lanthanide, Crystal Engineering, Reticular Synthesis, Hybrid Materials*

Acknowledgements:

Professor Anthony K. Cheetham and his FIHM research group at The University of Cambridge, Cambridge, U.K.
Professor Christopher L. Cahill and his research group at The George Washington University, Washington, U.S.A.

Authors' Biographical Notes:

Zeyar Min *is a doctoral candidate and teaching assistant in the Department of Chemistry, The University of the West Indies under the joint-supervision of Dr. Marvadeen Singh-Wilmot (Mona) and Dr. Richard Taylor (St. Augustine). His work focuses on the rational design, synthesis and characterisation of Lanthanide based Hybrid Materials for photoluminescent applications. Mr. Min is in the final stages of the submission process and is currently working on a number of publications, as well as pursuing new research ideas as he explores his post-doctoral options.*

Marvadeen Singh-Wilmot *is a Lecturer in Inorganic Chemistry at The University of the West Indies, Mona. Her research expertise includes rare-earth chemistry, hybrid materials, X-ray crystallography and photo-electronic characteristics of luminescent materials. She has authored numerous articles as well as a book titled 'Dipicolinic Acid, its Analogues and Derivatives; Aspects of their Coordination Chemistry'. Dr. Singh-Wilmot has a passion for science and has been recognised for her outstanding research having been awarded the best research publication award in 2014 and 2018 at the UWI Principal's Research Awards. She is also the first Caribbean national to be inducted as a Young Affiliate Fellow of The World Academy of Sciences (TWAS) and is currently a member of The Young Affiliate Network (TYAN).*

Richard A. Taylor *holds a PhD in Chemistry from The University of the West Indies, Mona Campus. He has been twice visiting scholar at the Schools of Chemistry and of Materials, University of Manchester, UK, working with Professor Paul O'Brien FRS and visiting scientist at the Brookhaven National Laboratory, USA. He is currently Lecturer in Materials Chemistry at The UWI, St. Augustine Campus, Trinidad. There, through a small research group of PhD students Dr. Taylor has foccused his research on optoelectronic materials including, novel metal-organic liquid crystals, chalcogenide semiconductor thin films and nanomaterials (quantum dots) and luminescent metal-organic frameworks (through collaboration with Marvadeen Singh-Wilmot).*

■

A Portable Modular Mechanised System for In-field Transporting of Harvested Cocoa

Daniel Hosein[1], Robert A. Birch[2], Renique Murray[3], and Cilla Pemberton[4]

Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies;

[1]Email: danielhosein@hotmail.com;
[2]Email: Robert.birch@sta.uwi.edu;
[3]Email: Renique.murray@sta.uwi.edu;
[4]Email: Cilla.pemberton@sta.uwi.edu

Abstract: *Presently in Trinidad, cocoa is manually transported in bags on farmers' backs. This is a very tedious and time-consuming activity. This paper describes the design, fabrication and testing of an innovative, modular mechanised system that transports and weighs the cocoa within the field. The design consisted of a rigid frame that supported a motorised conveyor belt. The frame was foldable and modular and therefore allowed for additional length of conveyor system. The design process used Computer Aided Engineering (CAE) to first develop the concept and perform virtual testing on the design. The design was then fabricated and tested for functionality and efficiency. Cost efficiency or cost per metre-hour of operation and machine efficiency were assessed. Experiments showed that the cost efficiency and machine efficiency were optimum between 0^o to 15^o slope despite speed and load variations. This design would improve the time taken to move the cocoa and reduce post-harvest losses.*

Keywords*: Cocoa, Design, Computer Aided Engineering, Mechanised, Modular, Field Transport*

1. Introduction

There is no motorised form of transportation used in the cocoa farm sector in Trinidad and Tobago. Farmers from San Antonio Estate confessed that there is no affordable option for transportation of cocoa within the fields due to the terrain and soils of the land. This shows that only manual labour is used for transporting the cocoa from the cocoa trees, to the point of transporting the cocoa to the fermentation process. This means the farmers must manually carry the bags of cocoa from within the field to their trucks, which will then transport the cocoa to fermentation. As a result, this tedious and laborious job has deterred young farmers from joining the cocoa sector. The long-term economic effect this can have is physical damage to farmers, less harvesting of cocoa by farmers as they get older and less people will choose to want to become a cocoa farmer.

Moreover, this manual process can decrease the quality of the cocoa since it is being exposed to the environment for long periods of time as well as being physically damaged by the tossing and movement from the farmers. For a portable conveyor system, there are essentially three factors that will affect the performance of the machine: angle of slope of the conveyor belt, speed and the load applied to the conveyor belt. The proposed design will take into consideration these factors. During the performance testing, and an analysis of the factors against performance criteria will be conducted to determine the validity of this hypothesis and the degree, if any, to which they inhibit efficiency.

2. Background

2.1 Post-Harvest Train

Cocoa pods take approximately 5-6 months to become fully mature and ready to be harvested. The sign of a mature pod that is ready to be harvested is observed from the change of colour of the pods. Green pods turn yellow and red pods turn orange (Seedial 2009). The pods of the cocoa tree are manually harvested by using a sharp blade. The location of opening the pods can vary, as some farmers open the pods in the farm, while some farmers open the pods in the fermentation area. Once the pods are harvested, the cocoa is transported manually from the fields to the fermentation area where the cocoa will be treated and made into chocolate (ICO, 2012).

Harvesting cocoa pods is a very labour-intensive process. On West African small-holdings, the whole family, together with friends and neighbours assist in the fields. They gather ripe pods every few weeks during harvesting season, using large knives which are attached to poles. These pods are then placed on the farmers' heads as they

carry the pods to be split. Once the pods are split open, the seeds are removed and undergo a two-part curing process called fermentation and drying. This is the first stage in the entire process of making chocolate (Cadbury 2014).

2.2 Post Harvesting Considerations

Post harvesting of cocoa has an integral part in the production of cocoa. There are many considerations when considering methods of transporting cocoa from the fields to fermentation. The following are factors that can affect cocoa beans and thus, must be considered when designing transportation for the cocoa beans.

- Temperature – This is a crucial factor that plays a significant role in the entire post harvesting process. If the temperature of the cocoa beans is higher or lower than the ideal range of less than 30°C, over fermentation can occur and this can contaminate the taste and smell of the cocoa beans.
- Humidity/Moisture – Humidity and moisture content also affect the quality of the bean. If the moisture is too low (less than 6%), the cocoa bean can become brittle or if it is too high (greater than 8%), there is risk of mold. This damages the bean and will reduce the quality of the bean. Thus, having the cocoa beans exposed to the environmental conditions during post-harvest activities can create an inferior quality of cocoa beans. Figure 1 show that mold is found in bags of Cocoa due to high moisture.
- Mechanical Influences – Point loads such as hooks may damage the bag and cause tears which can lead to decreased strength of the bag and increased change of failure, along with, exposure to moisture and head which can affect the quality of the cocoa beans. (Deutschen 2002)
- Movement of Beans – If the cocoa beans are moved around too much, this can adversely affect the bean itself and can physically damage it, causing the bean to become futile. (Kongor 2016)

It must be noted that the longer the cocoa beans remain in the open environment, the more likely it is to become contaminated. Therefore, a fast and safe method of transport is ideal for cocoa transportation.

Figure 1: Mold Found in Bags of Cocoa due to High Moisture

2.3 Conveyor Belt System

A conveyor belt system is a mechanism consisting of at least two pulleys that is wrapped around by a belt. This belt is then rotating in endless loops with the objective of transporting an item from one location to another. This is done with endless procession of hooks, gears, buckets, and a wide belt. The belt is then supported by a series of rollers along the path. The rollers in the center of the device prevents the conveyor from sagging in the middle while it is carrying a load. The pulleys are engaged using a motor that will spin them at constant speed for a load. The motor only needs to rotate one pulley as this will induce motion of the second pulley. The pulley that is powered by the motor is called the driver pulley and the unpowered pulley is called the driven pulley. If there or other pulleys involved in the mechanism, they are generally called idler pulleys.

There are different components of a conveyor belt system, such as: 1) The belt, 2) The pulleys, 3) The motor, 4) The internal rollers/ slider bed, 5) The frame, and 6) The support. There are many advantages of using a conveyor belt system over another system or using manual labour. The advantages are:

- Durable and Reliable
- Automated
- Efficient
- Can transport a wide range of items
- Low maintenance
- Can be used in any environment

2.4 Conveyor Belt Weighing

In the cocoa industry, the weight of the cocoa is needed, along with its volume. There is a term for this called dimensional weight. This is necessary so that the farmers can have an idea of the yield of the crops. The bean size is important for the fermentation process. Therefore, the bean size can be determined from the weight and or volume of the bag (Jenson 1994).

Conveyor belts can be equipped with sensors that can output the weight of a point load. This can be considered as a conveyor belt scale. Thus, conveyor belt scales employ rollers into the system by either replacing a roller or in additional to existing rollers. The belt will be placed on the sensor and the load (cocoa) presses on the sensor and the deflection is recorded. This deflection can then be turned into a weight measurement. This is generally the case and this type of sensor is called a weight sensor. Ideally, this device would combine the weight of the load with the speed of the moving conveyor belt to acquire a rate of flow of the load in conjunction with the total weight of the passing load (Dietrich 1994).

There are disadvantages to this device such as installation time is increased for the sensor. Also, the two-load cell device is situated in one position and receives the load force at one point. Thus, a portion of the torsional movement is sensed as a downward motion on the device and this can cause inaccurate measurements as it adds to the actual weight (Dietrich 1994).

Load cells positioned at specified locations along the conveyor can be used as another form of achieving the weight of the bag of cocoa. The output of the several loads can be summed, and an average can be calculated. This however, poses a disadvantage as the tension throughout the length of the conveyor will vary, giving rise to inaccuracies in the method (Flinth 1975).

3. Methodology

3.1 Description of Design

This design is a conveyor belt system. The assembly of the system is simple and user friendly. The conveyor can be attached /detached from a van. It therefore can be transported using its wheels. The body consists of 3 parts that are folded onto each other. Therefore, the user unfolds the body until it is completely flat. The legs extend to various heights, depending on the level of the ground, and a locking pin is placed in the hole and the weight of the conveyor locks it in place. The start-up of the conveyor belt system begins with the battery. The battery powers the motor, which turns the driving pulley. This pulley rotates the belt which in turn, rotates the driven pulley. Once the belt is moving at a steady speed, the cocoa beans can be placed on the conveyor belt. The belt transports the cocoa while the metal bed is used as a support for the belt. The cocoa is deposited into a bin which cushions the fall of the cocoa. It must be noted that this system was designed to withstand 30 pounds of cocoa beans as local farmers gave this weight as the heaviest load they carry. This is the main principle of operation of the system (see Figure 2).

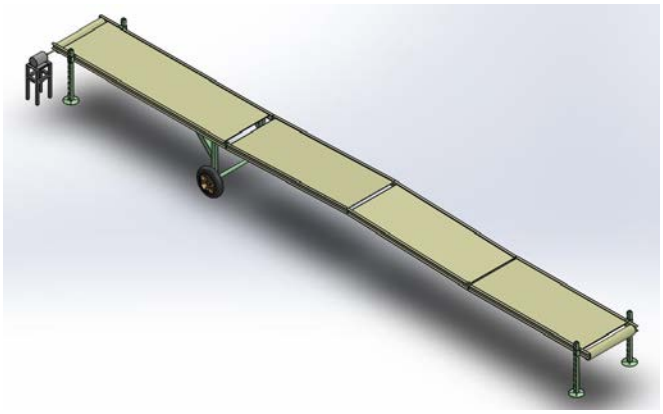


Figure 2: Final Design

3.2 Methodology for Testing and Analysis

The following are the steps to be taken to complete the testing of the conveyor belt system. For this testing, there are three (3) parameters that are known which are: the slope of the conveyor belt, the speed of the conveyor belt and the

load being applied to it. These parameters will be varied to produce variations in the values of the time taken for the loads to move a certain distance, the voltage and the current being produced by the motor.

1. Connect the 3hp motor shaft to the driving shaft of the conveyor system via a coupling.
2. Set-up conveyor belt such that the conveyor's bed and belt is parallel to the ground. That is, set the angle of incline, $\Phi = 0°$.
3. Start the motor and using the frequency drive, adjust the speed of the motor to 190 rpm.
4. Record the voltage and current at this speed and angle. Record the time taken for the belt to move from the beginning of the conveyor belt to the end of the conveyor belt.
5. Repeat step 4.
6. Add a five-pound weight onto the conveyor belt.
7. Record the voltage and current at this speed and angle. Record the time taken for the weight to move from the beginning of the conveyor belt to the end of the conveyor belt.
8. Repeat step 7.
9. Change the weight from five to ten pounds and repeat steps 7 and 8.
10. Change the weight from ten to fifteen pounds and repeat steps 7 and 8.
11. Change the weight from fifteen to twenty pounds and repeat steps 7 and 8.
12. Adjust the speed of the motor from 190 to 380 rpm and repeat steps 4 to 11.
13. Adjust the speed of the motor from 380 to 510 rpm and repeat steps 4 to 11.
14. Adjust the speed of the motor from 510 to 670 rpm and repeat steps 4 to 11.
15. Adjust the speed of the motor from 670 to 830 rpm and repeat steps 4 to 11.
16. Adjust the angle of incline from 0° to 7.5° and repeat steps 3 to 15.
17. Adjust the angle of incline from 7.5° to 15° and repeat steps 3 to 15.
18. Adjust the angle of incline from 15° to 22.5° and repeat steps 3 to 15.
19. Adjust the angle of incline from 22.5° to 30° and repeat steps 3 to 15.

The analysis of the results obtained from the test stated previously can be analysed using the raw data and by doing an ANOVA to further understand how the system behaves and more importantly, how does the slope, speed and load affect the efficiency, output power, slip and cost per metre-hour.

Firstly, place the raw data in a spreadsheet on excel. Next, run the raw data through the Minitab software to acquire mean values, f values and regression lines or equations. Finally, plot the relevant graphs and test to see if the regression equation is accurate by conducting tests with random slopes, speeds and loads, calculating the relevant values and comparing these values to the values obtained from the regression equations.

4. Design Approach and Analyses

The design phase was carefully considered to ensure the best design was produced. Firstly, a questionnaire was distributed to farmers to find out the average weight of the bag or bucket of cocoa that they carried along with the distances they needed to travel. With these parameters the length of the conveyor system was determined as well as the maximum weight being transported. Further to this, a factor of safety of 1.5 was added to ensure maximum safety. Next the conditions and terrain of the cocoa fields were inspected to determine the type of belt needed to withstand the environmental elements. Since the farmers harvest during both the dry and rainy season, the belt needed to withstand hot temperatures as well as wet conditions. The hilly terrain was noted and to compensate for this, moveable legs were introduced. The frame of the design was determined by uses stress calculations for varying situations such as impact loading, point loads and uniformly distributed loads. Buckling calculations were done to ensure the legs of the system were sturdy, strong and won't collapse. Upon completion of the manual calculations and design considerations, simulations were used to ensure the system will not fail.

A static simulation was performed on the entire design using SolidWorks. A uniformly distributed load of 89N was applied to the length of the conveyor bed, while the legs of the conveyor were fixed. The blue regions indicated the least amount of stress on the system while the green, yellow and red colours indicated the increasing stresses of the system and its respective locations. The maximum stress induced occurred at the center of the system at the hinges. This is to be expected since this point is located furthest from any support and as such the bending moment is maximum. All tested parts did not fail and showed that they will withstand the weight and forces that will be applied to them. The roller had the highest factor of safety of 78 which was an indication of overdesign. Both legs had much lower factors of safety, but they will still withstand the maximum forces applied. The plots also derived where the maximum stresses will occur so that careful attention can be made to these parts. Considering all the plots and the information they provided, these parts are safe to use and will not fail under the prescribed loading (see Figures 3-6. Besides, Figures 7 and 8 show a prototype of the design and have it folded for storage, respectively.

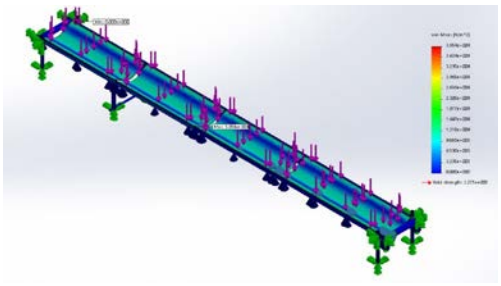


Figure 3: Stress Plot of Design

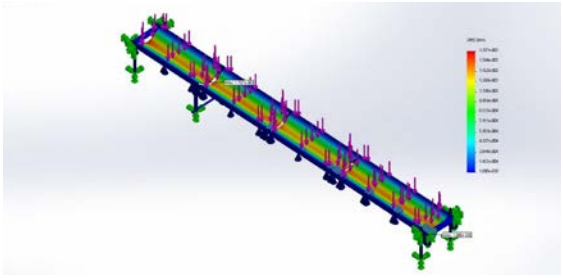


Figure 4: Displacement Plot of Design

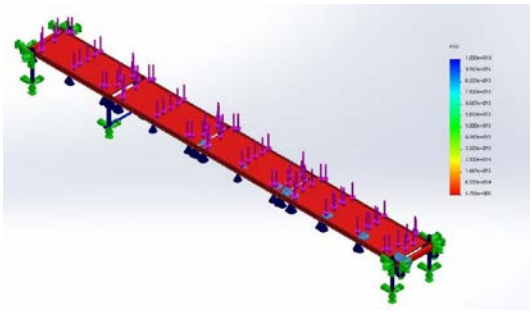


Figure 5: Factor of Safety of Design

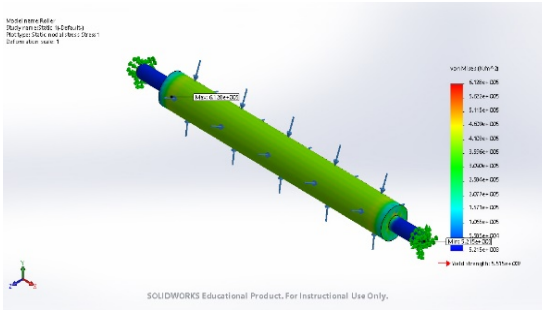


Figure 6: Stress Plot of Roller

Figure 7: Prototype of Design

Figure 8: Prototype of Design Folded

5. Results and Discussion

The results of the tests were tabulated, and an ANOVA was done. The following shows the main results achieved and how the proposed three factors affected the performance of the proposed prototype to give a clearer overview of how efficient and useful the conveyor belt system is, as this centres around the concept of the proposed design and prototype.

Figure 9 exhibits two lines of opposite gradients, that is, one line has an increasing or positive slope while the other has a negative or decreasing slope. The increasing slope represents the cost per metre-hour while the decreasing slope represents the efficiency of the system. These opposing gradients insinuate that efficiency and cost per metre-hour are inversely proportional to each other. Incorporating this discovery with slope shows that as the slope increases, the efficiency decreases and causes the cost per metre-hour to increase. This finding holds since efficiency is how well the system operates, and if the system is not operating to its full potential, it will require more power per metre-hour, and hence, will require more cost to complete the task. It is further observed that after 15°,

the cost per metre-hour increases quicker as the efficiency starts to decrease rapidly which implies that beyond 15°, the system becomes costlier.

Figure 10 shows an interesting comparison between efficiency, cost per metre-hour and speed. The efficiency and cost per metre-hour both increase with speed. The speed as stated before incurs a higher efficiency as it is increased. The increase in speed demands a greater input power, leading to an increase in the cost of the system. Furthermore, this same increase in speed increases the output power by the equation which states that output power is the torque by angular velocity. Thus, the increase in output power also increases the efficiency. Therefore, there can be an increase in efficiency while still having an increase in cost and the two are caused by the increase in speed.

Figure 9: Efficiency and Cost per Metre-Hour vs Slope

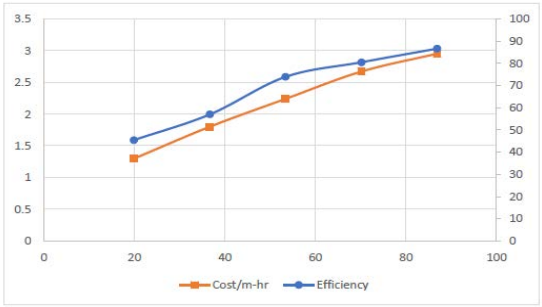


Figure 10: Efficiency and Cost per Metre-Hour vs Speed

Figure 11 shows how load affects efficiency and cost per metre-hour, and the interaction between efficiency and cost. It is observed that the beginning of the graph has a steep drop in both cost and efficiency as load is applied. Since there is a small load, the torque required to pull the load is small and thus the output power is smaller. This correlates to efficiency which will be, as a result, low. Taking this one step further, if there is low power then the cost per metre-hour will be lower. The graph in Figure 43 validates this. However, as the load increases, so does the efficiency and the cost. Beyond 67N of force, the cost per metre-hour surpasses efficiency. Additionally, the cost per metre-hour is the highest for load than any other factor. Thus, it can be deduced that beyond 67N the system no longer becomes economical.

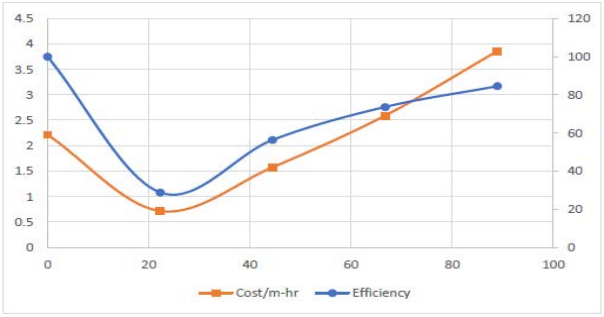


Figure 11: Efficiency and Cost per Metre-Hour vs Load

The following regression equation displays how each factor considered, affects the parameter required. Once a regression analysis is done, it displays the factors in an equation form and shows if, overall, they are significant, as well as, if each individual factor is significant to the parameter.

Efficiency = 34.4 – (0.151 x slope) + (0.632 x speed) + (0.062 x load)

Slip = -0.14 + (0.00618 x slope) + (0.00785 x speed) + (0.00229 x load)

Cost per Metre-Hour = -0.541 + (0.0244 x slope) + (0.025 x speed) + (0.0232 x load)

The R_2 value was 24.30% for efficiency. This indicates that the points are not very close to the regression line and as such a further stepwise analysis should be conducted for clarification. The R_2 value was 86.00% for slip. This showed that all the factors did in fact affect the slip, thus solidifying the hypothesis. Finally, the R_2 value was

51.00%. this indicated that slope, speed and load are significant in determining the cost per metre-hour of the system.

Thus, the experiments showed that the cost efficiency and machine efficiency were optimum between a 0^{o} to 15^{o} slope despite speed and load variations. This indicates that once the proposed design is within a 0^{o} to 15^{o} slope, there will be maximum efficiency and will be more productive to farmers than their current choice of movement. This range of slope can be maintained by the design having moveable legs to counteract the varying terrain. Furthermore, the cost per metre-hour equation was developed so that the farmers can essentially determine how much cost will be incurred due to the proposed design or the addition of more than one system since the design was developed to be modular.

6. Conclusions

The objectives of this project were achieved and are stated below:

- A Portable Motorised Conveyor Belt Harvester for the transportation of cocoa within the field. The conveyor belt system was built and fully functional for use in the cocoa field.
- A simple, safe and easy to operate system was built. The system was mobile buy folding the entire conveyor system and using wheels to easily move the system. This method ensured that the system was simple and easy to maneuver. Operation of the system was simplified as the system used a frequency drive to vary the speed which also has a start and stop switch for convenience.
- The design was tested for functionality and accuracy, 250 tests were conducted, which varied different parameters for functionality at multiple scenarios. The system withstood all scenarios.
- The system was tested for efficiency at different parameters such as slope, speed and load changes. A statistical analysis of the results was conducted to determine how these factors affected the system and determined the most and least efficiency combination of these parameters.
- The analysis of the test led to the determination of an invaluable factor which is cost per metre-hour. This factor showed how the cost per metre-hour required to run the system varied with the variation of the three factors.
- Regression equations were done for efficiency, slip and cost per metre-hour. This was done so that these three parameters could be determined for any slope, speed and load. It was solidified that all three factors did have an impact in the parameters stated previously.
- A bin was implemented to secure the cocoa at the end of the conveyor belt. Furthermore, the bin was also designed to measure the weight of the cocoa for instant acknowledgement of the yield of the cocoa from each individual tree or groups of trees.

References:

Bekele, F.L. (2004), *The History of Trinidad and Tobago*, The University of the West Indies.

Cadbury (2014), "Harvesting and Processing Cocoa Beans", *Cabury*. Available from: https://www.cadbury.com.au/About-Chocolate/Harvesting-and-Processing-Cocoa-Beans.aspx. Accessed October 21, 2017

Deutschen (2002), "Cocoa/Cocoa Beans." *Transport Information Service.* Available from: http://www.tis-gdv.de/tis_e/ware/genuss/kakao/kakao.htm#mechanische einfluesse. Accessed October 15, 2017

Dietrich, R. (1994), *United States of America Patent US 5338901 A.*

Flinth, R. (1975) *United States of America Patent US3924729 A.*

Forester. (2008), "Rotational Dynamics", August 25. Available from: http://web.mit.edu/8.01t/www/materials/modules/guide13.pdf. Accessed 4 8, 2018

Hellman, R. (2016), "Exploring Banana Production in a Costa Rica Plantation", *Recreation News.* May 26. Available at: http://recreationnews.com/2016/05/26/exploring-banana-production-at-a-costa-rica-plantation/. Accessed October 12, 2017.

ICO (2012), "Harvesting of Cocoa", International Cocoa Organisation, April 03. Available from: https://www.icco.org/about-cocoa/harvesting-and-post-harvest.html. Accessed October 21, 2017

James, D. (2011), "DC Motors", *Electrical Questions Guide.* May 07, Available at: http://electricalquestionsguide.blogspot.com/2011/05/dc-motors-advantages-disadvantages-ac.html. Accessed October 17, 2017.

Jenson, S. (1994), *United States of America Patent US5331118 A.*

Kongor, J. (2016), "Factors influencing quality variation of cocoa", *Food Research International*, January 18. Available from: https://www.researchgate.net/publication/291139941. Accessed November 10, 2017

Lewis, S. (2013), "Motors and Drives", *Engineer Live.* February 21. Available from: http://www.engineerlive.com/content/21329. Accessed October 25, 2017.
Mann, D. (2015), "A conveyor is only as good as its belt", *Bastian Solutions.* Available from: https://www.bastiansolutions.com/blog/index.php/2013/12/12/conveyor-belt-types-and-applications/#.WcGvbMiGPIU , Accessed November 10, 2017.
Phillips, R. (2003), "Overhead Conveyor Closed Track", *Pacline Overhead Conveyors.* February. Available from: https://www.pacline.com/enclosed-track-conveyor-advantages/. Accessed November 10, 2017.
Queensland (2009), *Quad Bikes on Farms.* August.
Seedial, M. (2009), *Cocoa Production*, Ministry of Agriculture, p.22-23.
SSSA (2017), "Soils Overview", Soil Science Society of America. Available from: https://www.soils.org/files/about-soils/soils-overview.pdf.
TMI (2016), "An Introduction into Soils and Soil Terminology", The Macaulay Institute, available from: http://www.macaulay.ac.uk/soilquality/An%20introduction%20to%20soils,%20soil%20formation%20and%20terminology.pdf.

Authors' Biographical Notes:

Daniel Hosein *graduated from the Faculty of Engineering at The University of the West Indies in 2018 with a BSc in Mechanical Engineering. He is currently working as an Associate Professional with the University of the West Indies*

Robert A. Birch *is an Instructor with the Department of Mechanical and Manufacturing Engineering at The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies. He has a BSc and MPhil in Agricultural Engineering and is currently a PhD candidate in Mechanical Engineering. Mr. Birch is a professional engineer (R.Eng) with more than 23 years industry experience and a member of the Institute of Agricultural Engineers, U K (MIAgrE). His research interests are in the design and development of machinery systems and Computer Aided Engineering (CAE).*

Renique Murray *is associated with the Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies*

Cilla Pemberton *is a Lecturer in Industrial Engineering at the University of the West Indies. She has 20 years' experience in manufacturing and business development respectively and her research interests include: Innovation, Entrepreneurship, Industrial Upgrading, Economic Development in Small Island States and Value Stream Analysis of Indigenous Industries.*

■

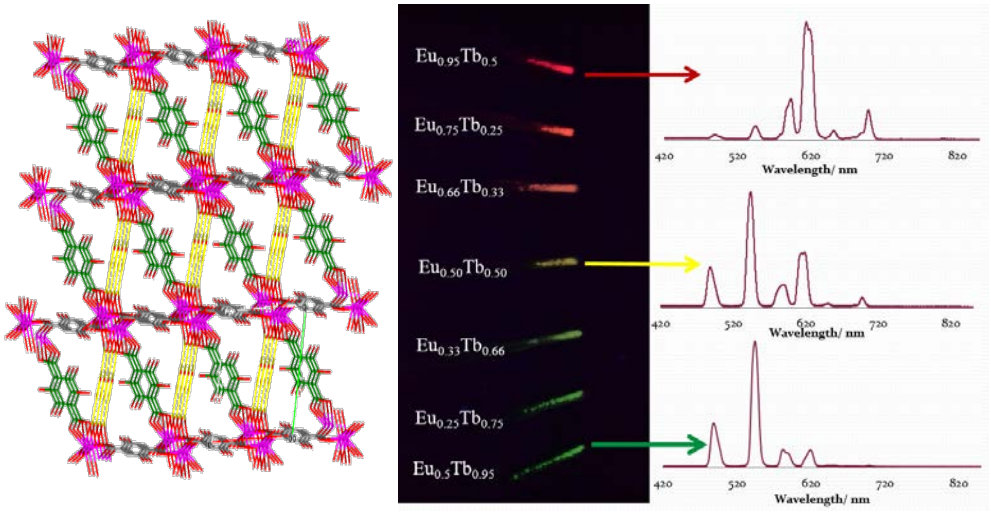
Synthesis, Characterisation, Luminescence and Sensing Capabilities of a New 2-Hydroxyterephthalate Lanthanide MOF

Christopher Hossack[1], Zeyar Min[2], and Marvadeen Singh-Wilmot[3]

[1,3] Department of Chemistry, University of the West Indies, 2 Plymouth Close, Mona, Jamaica, West Indies:
[1]Email: christopher.hossack@mymona.uwi.edu;
[3]Email: marvadeen.singhwilmot@uwimona.edu.jm

[1,2] Department of Chemistry, University of the West Indies, Circular Road, St. Augustine, Trinidad and Tobago, West Indies; Email: zeyar.min@uwimona.edu.jm

Abstract: *A novel metal-organic framework (known as UWIMOF-6), with formula, $Ln_2(htp)_3(DMF)_4 \cdot nDMF$ [Ln= Eu^{3+} (1), Gd^{3+} (2), Tb^{3+} (3), Er^{3+} (4) and htp = 2-hydroxyterephthalate] was successfully synthesised under reflux conditions, and its luminescence and sensing properties were investigated. The solid-state photoluminescence of 1 and 3 reveal that htp is an efficient sensitiser for Eu^{3+} and Tb^{3+} emissions at room temperature and 77 K. Mixed Eu^{3+}/Tb^{3+} samples result in tunable ratiometric luminescence, where varying the amounts of Eu^{3+} or Tb^{3+} gives different emission colours. The samples were also investigated for their sensing capabilities of small molecules such as acetone, methanol, metal ions and explosive nitroaromatics. Compound 3 exhibits the greatest promise for selective sensing of Al^{3+} and dinitrophenol. This study is the first reported case of lanthanide metal-organic frameworks (MOFs) from the stock ligand, 2-hydroxyterephthalic acid, and highlights their potential as tunable luminescent MOFs with interesting sensing capabilities.*



Left: Crystal structure of UWIMOF-6 along ac axes. Right: Tunable luminescence and respective red, yellow and green emission spectra of UWIMOF-**6** based on the relative concentrations of Tb^{3+} and Eu^{3+}.

Keywords*: Metal-Organic Frameworks, Lanthanide, Tunable Luminescence, Small Molecule Sensing, 2-Hydroxyterephthalate.*

Authors' Biographical Notes:

Christopher Hossack *is a third year undergraduate research student at The University of the West Indies, Mona, pursuing a Special Degree in Chemistry. He joined the Singh-Wilmot group in June 2018 and has done work in the photoluminescent sensing of small molecules using Lanthanide hybrid materials as well as the insertion of first row Transition metals into Lanthanide MOF systems. Future research interests include studying upconversion and single molecule magnet behaviour in Lanthanide complexes and supramolecular assemblies with carbon*

nanomaterials such as fullerenes and graphene. He is currently applying to post-graduate institutions to study supramolecular chemistry.

Zeyar Min *is a doctoral candidate and teaching assistant in the Department of Chemistry, The University of the West Indies under the joint-supervision of Dr. Marvadeen Singh-Wilmot (Mona) and Dr. Richard Taylor (St. Augustine). His work focuses on the rational design, synthesis and characterization of Lanthanide based Hybrid Materials for photoluminescent applications. He is in the final stages of the submission process and is currently working on a number of publications as well as pursuing new research ideas as he explores his post-doctoral options.*

Marvadeen Singh-Wilmot *is a Lecturer in Inorganic Chemistry at The University of the West Indies, Mona. Her research expertise includes rare earth chemistry, hybrid materials, X-ray crystallography and photo-electronic characteristics of luminescent materials. She has authored numerous articles as well as a book titled 'Dipicolinic Acid, its Analogues and Derivatives; Aspects of their Coordination Chemistry'. Dr. Singh-Wilmot has a passion for science and has been recognized for her outstanding research having been awarded the best research publication award in 2014 and 2018 at the UWI Principal's Research Awards. She is also the first Caribbean national to be inducted as a Young Affiliate Fellow of The World Academy of Sciences (TWAS) and is currently a member of The Young Affiliate Network (TYAN).*

■

The Use of Web-based Geographical Information Systems (GIS) and Data Visualisation Tools for Productivity Measurement in the Public Sector

Hollee Roberts[1] and Ruel L.A. Ellis[2]

Department of Mechanical and Manufacturing Engineering, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies:
[1]Email: holleeroberts25@hotmail.com;
[2]Email: Ruel.Ellis@sta.uwi.edu

Abstract: *The purpose of this study is to evaluate the efficiency and effectiveness (productivity) of Trinidad's public secondary schools using a web-based geographical information systems (GIS) GIS and economical modelling principles, multinomial logit model and regression analysis. The study will entail a rigorous examination of literature to determine the current productivity measurement systems in use in the public sector, particularly in the education sector. Both official and unofficial productivity methods will be observed. The application of Economic Methods of Investigation and Analysis will be used in conjunction with GIS technology to calculate and assign productivity scores to each of the N, numbers of sample schools in the pilot study. The efficiency scores will then be utilised in two stages of the study. Firstly, using variables selected from referencing scholarly literature sources, a series of Methods of Economic Investigations will be conducted (linear and non-linear regression analysis) to identify which factors impact efficiency i.e. the identification of statistically significant variables. Some of the potential independent variables (input parameters) are as follows; total student enrollment, the ethnicity-mix ratio of students, the percentage of financially challenged students, teacher-to-student ratio, teachers' average years of experience, the percentage of teachers with bachelor's degrees and the average teacher's salary. Secondly, using the identified statistically significant variables the efficiency for each school zone can be calculated. Then combining the scores with student achievement (CXC, CSEC and CAPE) a Productivity Measurement Index can be derived (using the assumption that productivity equals efficiency combined with effectiveness) these Key Performance Indicators (KPI's) will be mapped to allow spatial visualisation and analysis using a web-based GIS. In other words, the data can then be presented by plotting a graph of student achievement (x-axis) versus their efficiency which is categorised by zones using spatial data. Finally, a thorough sensitivity analysis (Return to Scale and Hybrid Return to Scale) of the data will be conducted to draw conclusions and make recommendations. This study aims to contribute to the body of knowledge as a source of literature on increasing efficiency of public-sector productivity measurement by adding the spatial dimension to economic data. Many modern government agencies are using GIS data in the private sector to analyse efficiency in economics, engineering, and business management. This will serve as a source of research on implementing as a productivity measurement method for analysing public secondary schools.*

Keywords*: Geographical Information Systems, Data Visualisation, Productivity Measurement*

Authors' Biographical Notes:

Hollee Roberts *is presently pursuing MPhil study in Industrial Engineering at the Department of Mechanical and Manufacturing Engineering, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies*

Ruel L.A. Ellis *is a Lecturer and Programme Coordinator of the MSc Programme in Project Management at Faculty of Engineering, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies*

■

Developing a Casebook of Quality Management Practices of Industrial enterprises in Trinidad and Tobago: An Agenda

Kit Fai Pun

Department of Mechanical and Manufacturing Engineering, The University of the West Indies, St Augustine, Trinidad and Tobago, West Indies. E-mail: KitFai.Pun@sta.uwi.edu

Abstract: *Competitive environments and priorities change over time. Effective enterprise management depends significantly on viable management structure and systems as well as measurement of performance and results. In today's organisation arena, quality cannot be achieved on a company-wide basis. Quality management (QM) has a mandate/act of overseeing company-wide activities and tasks needed to maintain a desired level of performance and excellence. MENG 6405: Total Quality Management (CRN: 20290) is one teaching course offered at Postgraduate Level in the Faculty of Engineering, The University of the West Indies (UWI). This paper starts with a brief review of quality evolution and explore the need to develop a casebook as a bench/reference text with tools and reading aids/guides in TQM and related areas in QM and systems, with particular reference to the local and the Caribbean contexts. A study agenda was initiated and elaborated along with the description of major stages of study execution and discussion of the deliverables.*

Keywords*: Total Quality Management, QM process and activities, performance, casebook*

1. Introduction

Sustaining and measuring organisational performance with quality management (QM) practices plays an influential impact on translating corporate strategy and incorporation of management structure and systems into results in organisations (Pun, and White, 2005; Lewis et al. 2006). Total quality (TQ) is far more than shifting the responsibility of detection of problems from customers to producers/providers. It involves a continuous improvement effort by everyone, top to bottom of the organisation to meet or exceed the users' satisfaction (Pun, 2018a). There is no exception for industrial enterprises across different sectors in Trinidad and Tobago (T&T), particularly with the recent adverse economic atmosphere in the Caribbean region.

Total quality management (TQM) is a comprehensive and fundamental rule or belief for leading and operating an organisation, aimed at continually improving performance over the long term by focusing on customers while addressing the needs of all stakeholders (Evans and Lindsay, 2011; Goetsch and Davis, 2016). It is both a philosophy and a set of guiding principles that represent the foundation of a continuously improving organisation. The bottom line of TQM is results: increased productivity, efficiency, customer satisfaction, and performance (Pun, 2001a, 2001b; Harold Aikens, 2011). This is a need to investigating into QM practices of industrial enterprises in T&T.

2. Evolution of QM Concepts and Systems

Quality management (QM) is concerned with management activities and functions involved in determination of quality policy and its implementation through means such as quality planning, control and assurance (Business Dictionary, 2018; Investopedia, 2018). Figure 1 shows an evolution of QM practices and systems. Camison (1998) summarise the evolution of quality systems into seven stages that underline the paradigmatic shift of QM practices towards TQM (see Figure 2). TQM integrates the development, maintenance and improvement efforts of various groups in an organisation. Several improvement initiatives/concepts are identified in association with TQM (Evans and Lindsay, 2011; Goetsch and Davis, 2016; Pun, 2018a). These are:

1) Customer Focus
2) Continuous Process Improvement – Kaizen
3) Employee Empowerment – Everyone is responsible for quality
4) Quality is free - focus on defect prevention rather than defect detection for it is always cheaper to do it right the first time
5) Benchmarking – Legally stealing other people's ideas
6) Customer-Supplier Partnerships
7) Management by fact, numbers and data (e.g., Balanced scoreboard; financial, customer, process, learning)

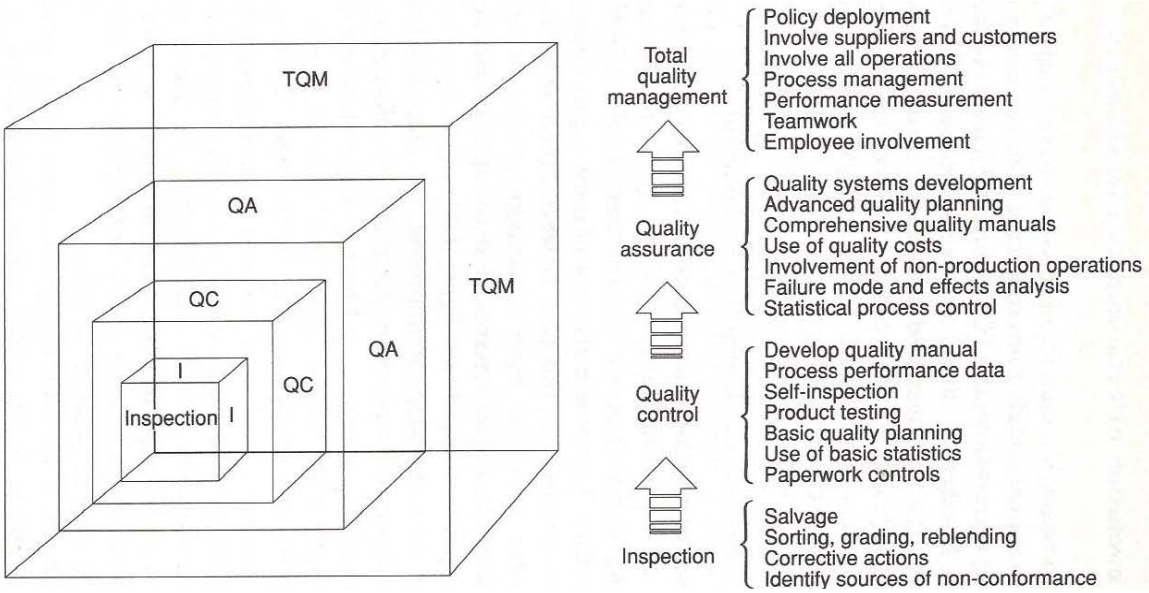


Figure 1. An evolution of QM practices and systems. Based on Pun (2008a)

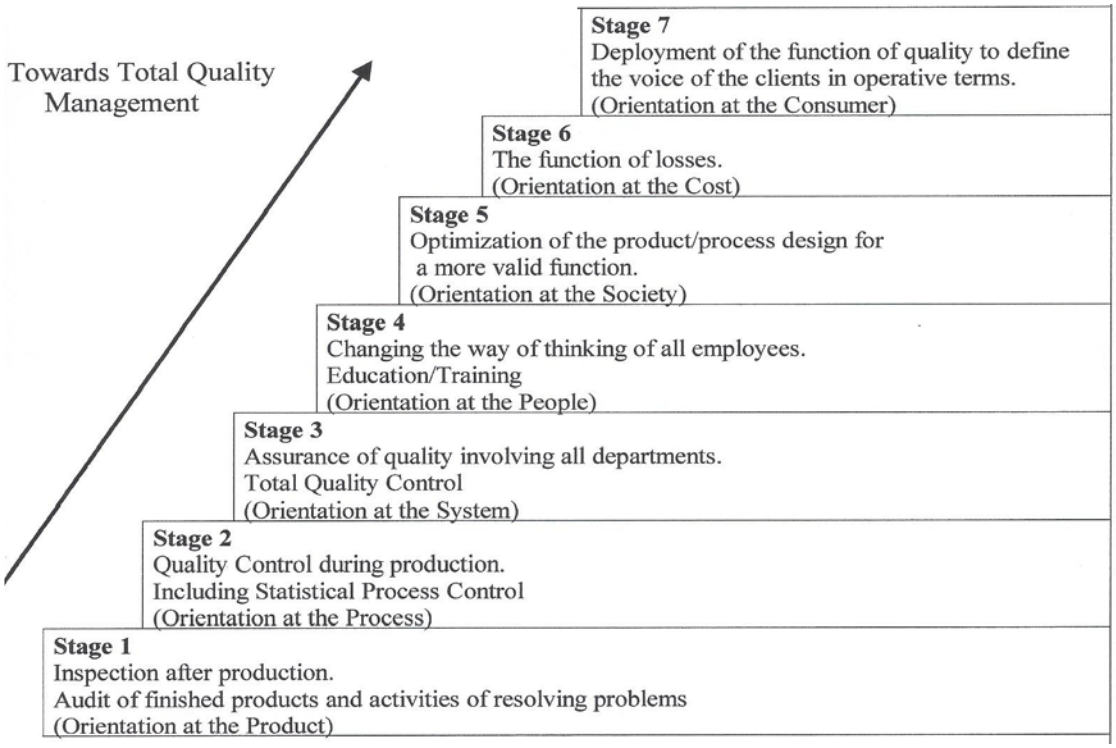


Figure 2. Evolution of quality systems Source: Based on Camison (1998, p.483)

TQM requires a comprehensive approach that must first be recognised and then implemented (Pun, 2018a). Other than following the advocates/teaching from quality gurus and experts (like Deming, Juran, Cosby, Feigenbaum, Ishikawa, and Taguchi, some common approaches of adopting/implementing TQM are 1) ISO 9000 and QM principles, 2) Integrated Management Systems and 3) Quality Awards/Business Excellence and Criteria.

3. A Proposal: Developing a TQM Casebook

TQM and related areas in quality management (QM) and systems are one research focus of The Industrial Engineering and Management (IEM) Research at the Department of Mechanical & Manufacturing Engineering (MME) at UWI-St Augustine Campus. MENG 6405: Total Quality Management (CRN: 20290) is one teaching course offered at Postgraduate Level in the Faculty of Engineering, The University of the West Indies (UWI). It forms part of the requirements for students reading for the MSc in Production Management, Production Engineering and Management, Engineering Management, Engineering Asset Management, and Manufacturing Engineering and management (Pun, 2018b). This course aims to provide students with the underlying principles and techniques of TQM with emphasis on their application to organisations. The purpose of this course is of two-fold. It aims:

1) To meet the educational needs of professionals, practitioners, managers and executives.
2) To explore opportunities for quality improvement and identify new directions in the areas of TQM leading to organisational performance excellence.

The subject synopsis of the MENG 6405 course includes (Pun, 2018b):

1) Principles of Total Quality (TQ) - Concepts of quality; Quality dimensions; Cost of Quality; Core values and paradigms for TQM, Vision, strategy, goals, and action plans.
2) Quality Management Systems and Approaches - QC/QA and QM, ISO 9000, Integrated Management System (Environment, Safety), Models for performance excellence: Deming Prize, Baldrige Quality Award, European Quality Award
3) Quality Culture and Leadership - Internal and external customers; Senior Management Leadership; Customer satisfaction and loyalty; Teamwork and people empowerment
4) TQM Methodologies – Total quality tools and techniques (such as, QC Tools, Quality Function Deployment (QFD); Statistical Process Control; Six Sigma; Taguchi Technique; Analytical Hierarchy Process; Benchmarking; Process reengineering and improvement)

For investigating into quality management practices of industrial enterprises in T&T, a study initiative was developed to develop a Casebook as a bench/reference text with tools and reading aids/guides in TQM and related areas in QM and systems, with particular reference to the local and the Caribbean contexts. The primary objective is to acquire and collate the materials and findings contributing to a Casebook publication (i.e., the deliverable). This serves as the starting/preparation part of a Casebook project in the next phase. The motive of writing the Casebook as a text/reference is to impart knowledge on the QM process and key QM activities in organisations with the local and Caribbean contexts.

It is intended to consolidate the performance-specific information from selected organisations and empirical findings acquired from interviewing selected industry practitioners and experts, so as to identify the factors affecting quality management practices and to explore the determinants for facilitating integration of TQM into performance measurement (PM) in industrial enterprises in T&T.

The materials would then be analysed and collated as inputs to the Casebook Publication that would incorporate subject synopsis, materials and QM cases/tools/guides for practitioners and professionals (including staff, graduates and students) who are engaging in QM process and key QM activities in organisations. The Casebook would initially contain 8-10 chapters, plus case studies and teaching guides on the following topics.

1) Introducing Quality and Productive Systems
2) Quality Management (QM) Systems and Approaches
3) Quality Culture and Leadership
4) Total Quality Tools and Techniques
5) Employee Empowerment and Team Building
6) Hoshin Planning and Quality Function Deployment
7) Statistical Process Control
8) Six Sigma Quality, Taguchi and Lean
9) Continuous Improvement, Re-engineering and Benchmarking
10) Team Dynamic, Conflicts and Communication

4. Methodology and Schedule of Study Execution

Execution of this project would combine the results of desk research and a review of current QM practices in T&T organisations, (ii) design of research framework and study instruments, (iii) acquisition/consolidation of subject synopsis, materials and QM cases, and (iv) reporting the findings and preparation for writing-up of draft chapters of

the Casebook. The project has four (4) stages and nine (9) tasks scheduled along the planned duration of 12 months in chronological order as shown in Table 1.

Table 1. Proposed Project Schedule, January – December 2018

Periods / Stages	**January - April 2018**	**May – August 2018**	**September - December 2018**
I	xxxx	xx	
II	x	xx	
III		xx	xxxx
IV		x	xxx

Remarks: 1 x stands for 1 month

Starting from the desk research, preparation for a Casebook Publication is the focus of this project. The project tasks overlap in individual stages to ensure their nature of continuity. These are elaborated separately as follows:

Stage I: Desk Research *(6 months)*

1) Conduct a desk research focusing on literature published in refereed journals in the subject synopsis for the past 20 years; and
2) Review available publications (including websites) of current QM practices from a group of selected/targeted industrial organisations in T&T.

Stage II: Design of research framework and study instruments *(3 months)*

1) Design a research framework that governs the acquisition of empirical data and case materials; and
2) Design study instruments and conduct the empirical data acquisition (via company visits, observation and interviews) with the group of industrial organisations.

Stage III: Acquisition/consolidation of subject synopsis, materials and QM cases *(6 months)*

3) Elicit empirical findings and case materials acquired the group of industrial organisations;
4) Diagnose/map the findings and case materials with supplementary materials collated from other sources in T&T and a wider Caribbean region; and
5) Consolidate materials of subject synopsis and QM cases.

Stage IV: Reporting the findings and preparation for draft chapters writing-up *(4 months)*

6) Prepare an interim progress report after the first six-month period;
7) Develop and refine the chapter plan and schedule for the writing-ups;
8) Prepare the materials for draft chapters writing-up and publication of the Casebook; and
9) Collate the findings and write up the final report at the end of 12-month period.

5. Deliverables and Conclusion

The core findings would be contributing to the preparation and publishing a Casebook/Bench text with QM tools/guides. It is anticipated that the outcomes this study (and the deliverables of the later Casebook project) will:

1) record cases that shed lights on QM practices and quality performance improvements in organisations, with the local and Caribbean contexts.
2) be a resources hub for QM practitioners and professionals (including staff, graduates and students); and
3) be a reference aid/text for those who enrolled in the MENG 6405 course and other quality-related courses offered in the Faculty of Engineering and other faculties at UWI-St Augustine Campus and other campuses.

It is expected that readers and users of the Casebook (bench text/reference) would explore and view quality from a variety of functional perspectives and in the process, gain a better understanding of the problems associated with improving quality, also quality tools utilised in both manufacturing and service sectors and in local/regional/ international environments.

Acknowledgements:

The author would like to thank the School fo Graduate Studies and Research to provide the financial support to this study via the Campus Research and Publication Fund CRP.3.NOV17.5

References:

Camison, C. (1998), "Total quality management and cultural change" A model of organisational development", International Journal of Technology Management, Vol.16, pp.479-493

Evans, J.R. and Lindsay, W.M. (2011), *Managing for Quality and Performance Excellence*, 8th edition, South-Western, Cengage Learning, Australia

Goetsch, D.L. and Davis, S.B. (2016), *Quality Management for Organisational Excellence: Introduction to Total Quality*, 8th edition, Pearson, Boston

Harold Aikens, C. (2011), *Quality Inspired Management: The Key to Sustainability*, Pearson Education, New Jersey

Lewis, W.G., Pun, K.F. and Lalla, T.R.M. (2006), "Exploring soft versus hard factors for TQM implementation in small and medium-sized enterprises", *International Journal of Productivity and Performance Management*, Vol.55, No.7, 2006, pp.539-554

Pun, K.F. (2001a), "Cultural influences of TQM adoption in Chinese enterprises: an empirical study", *Total Quality Management*, Vol.12, No.3, May 2001, pp.323-342

Pun, K.F. (2001b), "Development of an integrated TQM and performance measurement system for self-assessment: a method", *Total Quality Management*, Vol.13, No.6, September 2002, pp.759-777 (ISSN 1478-3363; Current Impact Factor: 1.323; Citations: 67).

Pun, K F. (2018a), "Quality Management Systems and Approaches" Lecture Notes 2, MENG 6405: Total Quality Management (CRN: 20290), Department of Mechanical Engineering & Manufacturing Engineering, The University of the West Indies, St Augustine, June 2018

Pun, K F. (2018b), Course Outline: MENG 6405: Total Quality Management (CRN: 20290), Revised Version, Department of Mechanical Engineering & Manufacturing Engineering, The University of the West Indies, St Augustine, June 2018

Pun, K.F. and White, A.S. (2005), "A performance measurement paradigm for integrating strategy formulation: a review of systems and frameworks", *International Journal of Management Reviews*, Vol.7, No.1, 2005, pp.25-46

Authors' Biographical Notes:

Kit Fai Pun *is presently Professor of Industrial Engineering of the Faculty of Engineering and the Chair and Campus Coordinator for Graduate Studies and Research at The University of the West Indies. He is a Registered Professional Engineer in Australia, Europe, Hong Kong, and The Republic of Trinidad and Tobago. His research interests and activities include industrial engineering, engineering management, quality systems, performance measurement, innovation, and information systems.*

■

A Mechanised Cocoa Dryer Chamber

Robert A. Birch[1], Rodney Seepersad[2], Renique Murray[3], Cilla Pemberton[4], and Edwin I. Ekwue[5]

Department of Mechanical and Manufacturing Engineering, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies:

[1]Email: Robert.birch@sta.uwi.edu;
[2]Email: rodneyseepers@hotmail.com;
[3]Email: Renique.murray@sta.uwi.edu;
[4]Email: Cilla.pemberton@sta.uwi.edu;
[5]Email: Edwin.ekwue@sta.uwi.edu;

Abstract: *The drying of cocoa using artificial methods has become significant due to issues associated with the conventional methods used by cocoa drying houses. In this project, a mechanised dryer was designed and fabricated to reduce the drying time associated with the drying of cocoa while still maintaining the quality of the dried bean. The dryer was scaled down to dry a 2kg of beans, the main features of the dryer included a rotational chamber or drum, an electric heater and air blower system. The beans were placed in the drum and exposed to heating and slow rotation. Drying of the beans were experimented using continuous, intermittent and no rotation (control) of the drum. An intermittent rotation of the drum of 6 rpm at 4 hour intervals, with a constant temperature of 60 ^{o}C and air velocity of 3.8 m/s provided the desired moisture content (dry basis) of 8.7 % and an overall dryer efficiency of 84.4 % at a reduced drying time of 12.5 hours. This makes this design a more effective dryer than existing conventional dryers.*

Keywords: *Cocoa, Design, Dryer, Mechanised*

Authors' Biographical Notes:

Robert A. Birch *is an Instructor with the Department of Mechanical and Manufacturing Engineering at The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies. He has a BSc and MPhil in Agricultural Engineering and is currently a PhD candidate in Mechanical Engineering. Mr. Birch is a professional engineer (R.Eng) with more than 23 years industry experience and a member of the Institute of Agricultural Engineers, U K (MIAgrE). His research interests are in the design and development of machinery systems and Computer Aided Engineering (CAE).*

Rodney Seepersad *is associated with the Department of Mechanical and Manufacturing Engineering, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies.*

Renique Murray *is associated with the Department of Mechanical and Manufacturing Engineering, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies.*

Cilla Pemberton *is presently Lecturer in Industrial Engineering at the Faculty of Engineering at The University of the West Indies (UWI). She obtained a Doctorate degree at the Arthur Lok Jack Graduate School of Business and has extensive experience in the manufacturing sector. Her qualifications include MSc Industrial Innovation Entrepreneurship and Management from The University of Trinidad and Tobago and MSc Production Engineering and Management and BSc Industrial Engineering from the UWI.*

Edwin I. Ekwue *is currently Professor and Dean, Faculty of Engineering at The University of the West Indies (UWI), St Augustine, Trinidad and Tobago. He is also Coordinator of the Biosystems Engineering Programme and was a past Head of the Department of Mechanical and Manufacturing Engineering. His specialties are in Water Resources, Hydrology, Soil and Water Conservation and Irrigation and Drainage. His subsidiary areas of specialisation are Structures and Environment, Solid and Soil Mechanics, where he has teaching capabilities. Professor Ekwue has served as the Deputy Dean for Undergraduate Student Affairs and Post-graduate Affairs and Outreach, as the Chairman of Continuing Education Committee, and as the Manager of the Engineering Institute in the Faculty of Engineering at The UWI.* ■

Anaerobic Microbial Degradation of Chlordecone in Microcosms from Guadeloupe Soil

Suly Rambinaising[1], Laurent Laquitaine[2], Ronald Ranguin[3], Corine Jean-Marius[4], Line Lomheim[5], Andrei Starostine[6], Luz A. Puentes[7], Elizabeth A. Edwards[8], and Sarra Gaspard[9]

[1-4,9] Laboratory COVACHIM-M2E, EA 3592, Université des Antilles, BP 250, 97157 Pointe-à-Pitre, Guadeloupe, France

[5-8] Department of Chemical Engineering and Applied Chemistry, University of Toronto; Canada;

[1] Email: ramb.suly@gmail.com
[2] Email: laurentlaquitaine@hotmail.com
[3] Email: ronald.ranguin@univ-antilles.fr
[4] Email: corine.jean-marius@univ-antilles.fr
[5] Email: line.lomheim@utoronto.ca
[6] Email:andrei.starostine@utoronto.ca
[7] Email: luzpuentes@gmail.com
[8] Email: elizabeth.edwards@utoronto.ca
[9]Email: sarra.gaspard@univ-antilles.fr

Abstract: *The use of chlordecone as the active ingredient in pesticide formulations has resulted in extensive pollution of large land areas in the French West Indies. These areas were treated with pesticides to control the banana black weevil. Although the use of these pesticides is currently banned, chlordecone strongly adsorbs to soil and is highly recalcitrant due to its complex bis-homocubane structure. However, under reducing conditions, abiotic chemical transformation involving Vitamin B12 has been reported to break down chlordecone to C_9 compounds, believed to be "open cage" structures. More recently, these C_9 compounds, assigned as polychloroindenes, were also observed as products from anaerobic biological transformation in bacterial consortia and isolated Citrobacter. In order to investigate the biodegradability of chlordecone, microcosms were constructed anaerobically from chlordecone impacted Guadeloupe soil and sludge. The microcosms were incubated and repeatedly amended with chlordecone and electron donor (ethanol and acetone) over a period of 7 years. During this time some transfers were made, and the microcosms were periodically analysed for chlordecone and potential degradation products using LC-MS, and methane using GC-FID. DNA was extracted from some of the microcosms, and the microbial community was analysed using 16S amplicon sequencing (Illumina MiSeq). Degradation products of chlordecone were detected in all the biologically active microcosms. Observed products include monohydro- and dihydrochlordecone derivatives ($C_{10}H_{10-n}O_2H_{n+1}$ n= 1,2), as well as C_{10}- and C_9-polychloroindene compounds ($C_9Cl_{5-n}H_{3+n}$ n=0,1) and carboxylic polychloroindene derivatives ($C_{10}Cl_{4-n}O_2H_{4+n}$, n=0-4) assumed to be "open cage" structures with significant dechlorination also shown in other studies which are not present in sterile controls. Chlordecone concentrations decreased in active microcosms. Results from microbial community analysis show enrichment of several organisms possibly involved in chlordecone biodegradation. In two microcosms with no methanogenesis, we see high relative abundance of Desulfovibrio and Sporomusa. In two of the microcosms with methane production, we see enrichment of two highly similar Anaerolinaceae species (Pelolinea and Leptolinea), Bathyarchaeota, and two methanogens (Methanoregula and Methanosaeta). Some metabolites identified in this study are also detected in the field, showing that a bioremediation process could be envisioned.*

Keywords*: Microbial Degradation, Chlordecone, Microcosms, soil science*

Authors' Biographical Notes:

Suly Rambinaising, Laurent Laquitaine, Corine Jean-Marius *and* Sarra Gaspard *are associated with the Laboratory COVACHIM-M2E, EA 3592, Université des Antilles, BP 250, 97157 Pointe-à-Pitre, Guadeloupe, France.*

Ronald Ranguin *is is an engineering study with COVACHIM M2E (Connaissance et Valorisation: Chimie des Matériaux, Environnement, Energie) Research Group at the Université des Antilles, in Guadeloupe, France. He received his BSc in Physical and Chemical Sciences from the University of Aix-Marseille (II), and an MSc in Physical Science in 2011 and a PhD at the Université des Antilles in 2015, in Guadeloupe, France. His work can be summarized as covering the following subjects: wastewater treatment, analytical chemistry, preparation of activated carbons, green chemistry, characterisation techniques, and adsorption.*

Line Lomheim, Andrei Starostine, Luz A. Puentes *and* Elizabeth A. Edwards *are associated with the Department of Chemical Engineering and Applied Chemistry, University of Toronto; Canada.*

■

Engineering Programmes and Economic Development in the SIDS of the Caribbean and South Pacific

Cilla Pemberton[1], John Pumwa[2], Rajeshkannan Ananthanarayanan[3], and Oneil A. Josephs[4]

[1] Department of Mechanical & Manufacturing Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies; Email: cilla.pemberton@sta.uwi.edu;

[2]Mechanical Engineering Department, PNG University of Technology, Lae, Papua New Guinea; Email: john.pumwa@pnguot.ac.pg;

[3]School of Engineering & Physics, Faculty of Science, Technology & Environment, The University of the South Pacific (USP), Laucala Campus, Suva, Fiji; Email: rajeshkannan.ananthanarayanan@usp.ac.fj;

[4]Faculty of Engineering and Computing, University of Technology, Kingston, Jamaica, West Indies; Email: ojosephs@utech.edu.jm;

Abstract: *The Small Island Developing States (SIDS) are well-known globally for beautiful sandy beaches and warm tropical climates which make them attractive as tourist destinations. Less recognised is the fact that they produce hundreds of engineering graduates on a yearly basis in programmes which are currently internationally accredited or in the process of seeking that accreditation. Notwithstanding the former, industries which are heavily based on engineering design, industrial and systems engineering, and other high-end skills of engineering graduates have not featured prominently among these nations' major contributors to Gross Domestic Product. This paper explores the potential role of engineering schools toward sustainable economic development in the SIDS of Fiji, Papua New Guinea, Jamaica and Trinidad and Tobago, using a conceptual framework for innovation in developing countries. It also utilises desk research, interviews and data from a Q-Study with a 36-item Q-Set to draw conclusions regarding the current major engineering programmes in the four (4) countries in support of this type of development. This study can contribute some insight as to the current realistic prospective contribution of locally trained engineering graduates toward sustainable economic development based on engineering entrepreneurship in the SIDS.*

Keywords: *Engineering, Entrepreneurship, SIDS, Caribbean, South Pacific*

Authors' Biographical Notes:

Cilla Pemberton *is presently Lecturer in Industrial Engineering at the Faculty of Engineering at The University of the West Indies (UWI). She obtained a Doctorate degree at the Arthur Lok Jack Graduate School of Business and has extensive experience in the manufacturing sector. Her qualifications include MSc Industrial Innovation Entrepreneurship and Management from The University of Trinidad and Tobago and MSc Production Engineering and Management and BSc Industrial Engineering from the UWI.*

John Yuahan Pumwa *is the Head of the Department of Mechanical Engineering and the Acting Dean of Engineering at the PNG University of Technology. He obtained his Master of Engineering with Honours from the University of Wollongong, NSW, Australia in 1991 in Mechanical Engineering. He obtained his Ph.D. from Texas A&M University in Interdisciplinary Engineering in 1997. Professor Pumwa has also been engaged as a Post-doctoral Fellow at Korea Advanced Institute of Science and Technology (KAIST), Mechanical Metallurgy Laboratory, Material Science and Engineering Department, Taejon, South Korea involved in various failure analysis projects and also in the development of high temperature steel in 2000. Professor Pumwa is a Fellow of the American Society of Mechanical Engineers (FASME) and the Institution of Engineers, PNG (FIEPNG), and also a Chartered Engineer and Member of the Institution of Mechanical Engineers (MIMechE), UK. Professor Pumwa has also been appointed as an Emeritus Professor at Shiri JJT University, India. Most recently, Professor Pumwa has been awarded as the Distinguished Educator Award by the International Operations Management Society (IEOM) in March 2018. Professor Pumwa has published more than 200 publications.*

Rajeshkannan Ananthanarayanan *is associated with Mechanical Engineering, School of Engineering and Physics, FSTE, USP, Suva, Fiji since 2008. He joined as Lecturer and raised up to Associate professor in 8 years term. His major research is in Materials, Manufacturing and Industrial Engineering. In particular, metal forming, metal additive, CNC machining and operations management are the area the research work has been carried out.*

Total of nearly 75 articles are made in this field in refereed journals and conferences. He set up powder metallurgy research lab for research purpose and developed metallurgy and manufacturing lab for BE Professional Mechanical Engineering programme. He earned BE, M.Tech and PhD in Mechanical Engineering from India and put up academic and research experience of 7 years in India itself before moved to USP, Fiji.

Oneil A. Josephs *is the Director of Industrial Engineering at the University of Technology, Jamaica (UTech), where he has been employed for the past ten (10) years. He heads the Department's Lean Enterprise Research Group (LERG), which has responsibility for providing third party support to industry in the use of Lean tools to improve efficiency and productivity in service and manufacturing operations. Oneil is a recipient of the prestigious Chevening Scholarship and a graduate of the University of Nottingham, UK where he completed his MSc in Manufacturing Systems. Oneil's research activities continue to evolve and to date he has made several local and international conference presentations. He is a former member of UTech's Academic Board and currently represents the University as an Associate Member of the Jamaica Manufacturers' Association. He is registered with the Jamaica Professional Engineering Registry Board and is a former professional member of the Institute of Industrial and Systems Engineers in the United States. His live was not always paved with success, but he believes that through God, and hard work, all things are possible.*

■

Investigating Fracture and Crack Propagation in Soils Using MATLAB: A Novel Technique

Robert A. Birch[1], Jacqueline Bridge[2] and Edwin I. Ekwue[3]

Department of Mechanical & Manufacturing Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies;

[1]Email: Robert.birch@sta.uwi.edu;
[2]Email: Jacqueline.Bridge@sta.uwi.edu;
[3]Email: Edwin.Ekwue@sta.uwi.edu

Abstract: *This paper describes the use of MATLAB algorithms to process and analyse the fracture and propagation of cracks in soils that were under dynamic bending loads. An experiment was designed to investigate the characteristics of tensile fracture and crack propagation in soils under dynamic loading. A special device was designed and fabricated to hold and subject rectangular soil samples of 140 mm x 25 mm x 25 mm, compacted to 404 kPa to dynamic loads at 10 Hz, 50 Hz and 100 Hz. Instruments measured the applied forces and accelerations of the samples at failure. Video images were captured during the experiments and were used as input data for analysing the behaviour of the soils. MATLAB algorithms were used to read, process and analyse the image data. Vital information on soils such as tensile failure strength, resilience, natural frequency, damping coefficient, flexural rigidity, crack length and crack opening angle were obtained. This information is useful as it characterises the behaviour of different soils under dynamic loads and would assist engineers who design implements that are involved in tillage or root crop harvesting.*

Keywords: *Characterisation, MATLAB, Fracture, Crack Propagation, Dynamic*

1. Introduction

During the formation of tilth, soils crumbles into smaller particles (Birch 2018). The crumbling of the soil matrix is a fracture process due to bending or tensile forces (Vocomil and Chancellor 1967). The mechanism of fracture has been previously investigated by Aluko and Chandler (2006) using quasi-static 3 point bending test. In this report, an instrumented dynamic soil tester was designed and fabricated. The dynamic soil tester is a modification of the 3 point bend test described by Aluko and Chandler (2006). Soil was moulded into beam samples that are loaded dynamically and the investigation into the mechanism of soil fracture involved factors such as soil type, percentage peat, consistency limit as well as the frequency of the movement of the tool. Image acquisition and analysis techniques were employed to quickly capture information on the fracture process and the propagation of cracks during loading of the soil samples.

Although quasi-static experiments yielded useful results (Hallet and Newson 2001; Birch 2018), dynamic testing may be able to unlock pertinent questions such as whether organic matter has any effect on the tensile failure and thereby in the formation of tilth when the frequency of loading varies. There have been limited dynamic experiments, though such experiments might be better representations of the actual tillage process. One such investigation performed by Karmarkar et al. (2005) used high speed video imaging to analyze displacement, velocity and acceleration of the crack created by a soil sweep implement. They identified that soil cracks exist in four stages and determined that crack growth rate has a sinusoidal response. What is lacking is a full laboratory experiment that investigates tensile failure in soils under dynamic loading. Such an experiment can investigate the factors of soil type, percentage peat, water state and frequency and their interactions. The major aim of this investigation was to determine the influence of factors such as percentage peat, water content, soil type and frequency on the resilience, tensile strength, modal properties of the soil and crack length under dynamic loads. The investigation seeks to characterise the dynamic behaviour of soils so that a comprehensive understanding of the fracture process in soils is attained. By quantifying the process, we can design and develop better implements to fracture and crumble soils and thereby optimize the process in forming tilth.

2. Experimental Methodology

Figure 1 shows the physical arrangement instrumented dynamic soil tester as developed by (Birch 2018) while Figure 2 shows an enlarged view off the dynamic tester with the test rig. Soil samples of dimensions 140 mm x 25 mm x 25 mm were prepared by varying mixtures of peat and water. There were two soil types, namely Piarco sandy

loam soil and Talparo clay soil. The peat content varied between 0, 4, 8 and 12 % while the water consistency limit was at the plastic limit and three levels in decreasing increments of 5, 10 and 15 % less than plastic limit.

Figure 1: Physical arrangement of Dynamic Tester (A), Signal processors (B) and Amplifier (C)

All samples were compacted at 404 kPa. The compaction level of 4o4 kPa best represents actual field conditions. A full factorial experiment was performed where experiments were conducted at three frequencies of 10, 50 and 100 Hz and the instrumentation for the research (Figure 3) used the LABVIEW VI environment (Sumathi and Surekha 2007). A wave generator sent sinusoidal signals to the shaker. The responses were sensed by a force transducer and accelerometer. The measurements were recorded with respect to time by the computer via the Data-Acquisition system (DAQ).

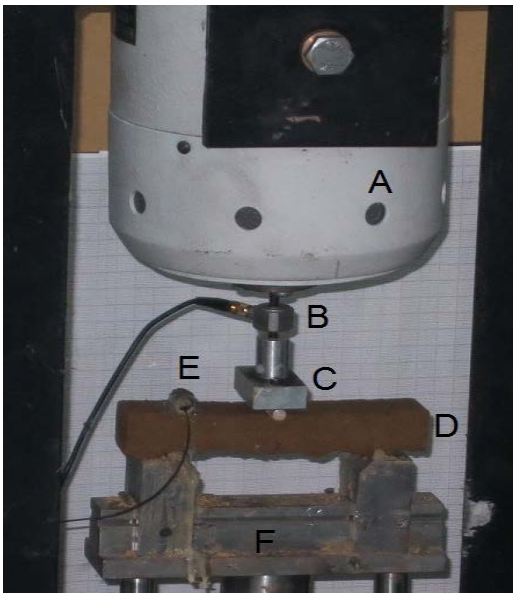


Figure 2: Enlarged View of Dynamic Tester with Adjustable Test Rig. (A) Vibrating Shaker Device; (B) Force Transducer; (C) Single point 6 mm diameter cylindrical tool; (D) Soil sample; (E) Accelerometer; (F) Adjustable Test rig; (G) HD camera

The LABVIEW software is a virtual software, where an algorithm was written to allow a sinusoidal signal to be sent to the tool and simultaneously obtained force and acceleration readings from the transducers. The experiments were halted when a failure occurred.

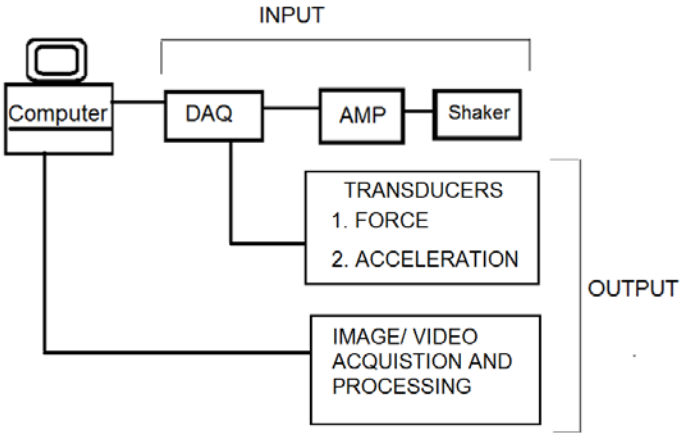


Figure 3: Sketch of Instrumentation set up

A failure was defined as the propagation of a crack of any form or a deformation that occurred on the soil when the tool engaged the soil (Figure 4). The LABVIEW program used a filter system to remove noise from the received data. The sampling rate theorem was applied (Wheeler and Ganji 2004) where the sampling rate (which in this case was 1000 Hz) must be greater than 2 times the maximum sampling frequency (i.e.100 Hz). A special switch was installed on the set up to ensure synchronization of the onset of the dynamic loading and the recording of the force and acceleration measurements.

Figure 4: A sample of Piarco soil at failure. Sample number S4 with 4% peat, 24% moisture content at 10 Hz

The acceleration and force measurements were recorded in units of mechanical units (MU). The digital image acquisition technique employed the use of a Logitech (C270) high definition (HD) computer web camera that captured videos of the process of fracture while the soil imposed vibrations on the soil samples. The two measurements of acceleration and applied force were taken during the experiments. A high definition (HD) camera permitted capture of videos of the experiment. The camera had the capability of recording 20 frames per second.

The data obtained from the experiments was large and challenging to analyse and interpret. For instance, a total of 384 samples were investigated and for each sample there was data on acceleration and applied force which usually had data files in text format ranging from 1,000 kB to 5,000 kB depending on length of time of the experiment. For the videos captured, the times ranged from 10 seconds to 1 minute and the data files had sizes ranging from 6000 kB to 20,000 kB respectively as Windows Media Video (wmv) files. The data on acceleration and applied force were recorded each micro-second (i.e. 0.001 s) as a voltage reading with a sensitivity of 1×10^{-6} volts and converted to Mechanical Units (MU). When the data was plotted against time, waveforms were obtained similar to those shown in Figure 5.

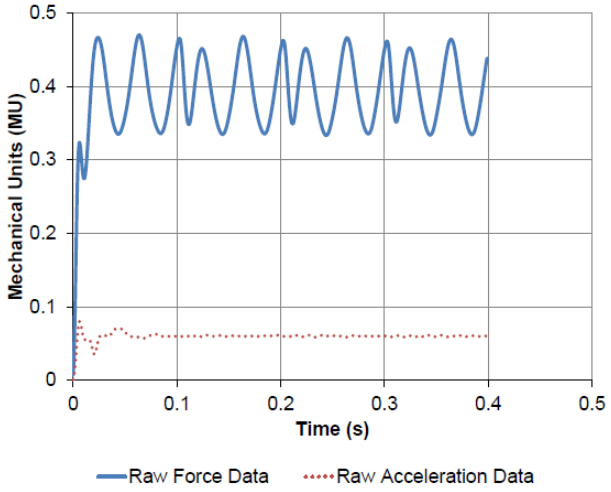


Figure 5: Plot of raw data of sample of Piarco soil. Sample number S4 with 4% peat, 24% moisture content at 10 Hz.

Two MATLAB algorithms were developed to process and calculate useful parameters from the source data. The first algorithm (MATLAB code-1) automatically read the force and acceleration data. The data was first processed by standardization which involved the subtracting of the no-load test values from the received data for each corresponding frequency. The values obtained were force and acceleration minus the influence of the weight of the attachment to the shaker and the transducers. The force and acceleration data were then converted to respective SI units of N and ms^{-2}. The conversion of 1 MU of force and acceleration were 89.18 N and 400 ms^{-2} respectively. The output of this process for a short duration of t = 0.5 seconds is shown in Figure 6.

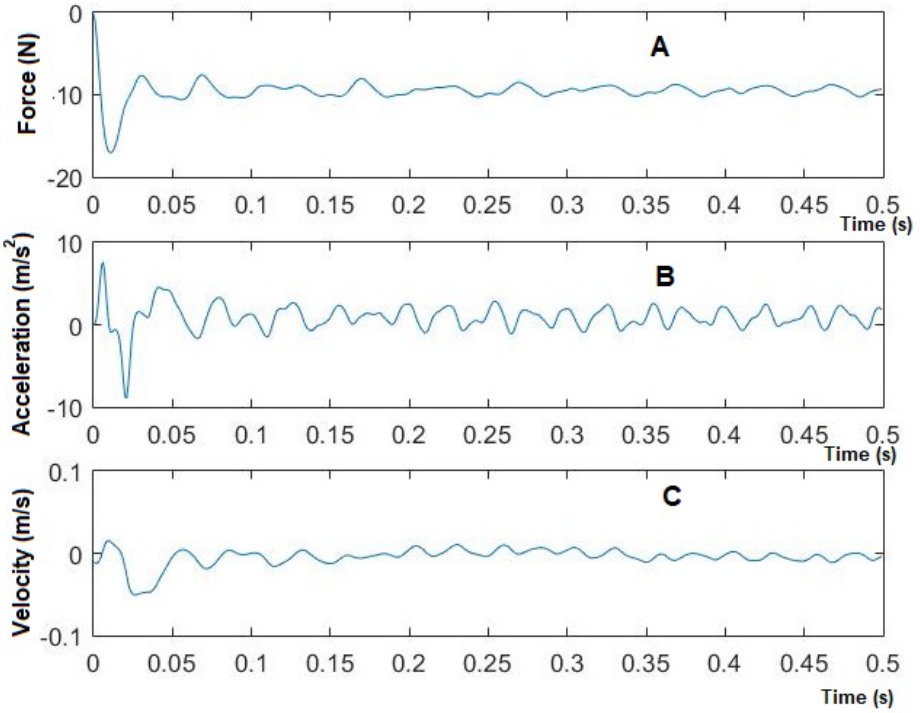


Figure 6: Plots of processed data of sample of Piarco soil. Sample number S4 with 4% peat, 24 % moisture content at 10 Hz during the processing by MATLAB code-1. A: Force data after removal of no-load effects and conversion from MU to N. B: Acceleration data after removal of no-load effects and conversion from MU to ms^{-2}. C: Calculated velocity data from ∫Bdt

An assumption was made that the crack initiation and propagation commenced when the acceleration values spiked during the dynamic test. The event was labelled crack start or time to failure and coincided with the largest acceleration value (|a|). The MATLAB code -1then calculated power based on the multiplication of force and velocity. Thereafter, energy was determined by integrating the power. The energy terms were separated into peak energy, root mean square energy and steady state energy values. These were converted to resilience by dividing by the volume of the samples. Tensile strength, natural frequency and the damping coefficient for each soil sample were also calculated. To calculate tensile strength, the soil sample was considered as a simply supported beam loaded in the centre. At the end of the process a table was generated with all the values of these parameters for all the soils examined.

The second algorithm (MATLAB code-2) used a non-contact imaging method and analyzed each video (see Figure 7) to determine information on crack length, crack opening angle (COA) and maximum deflection Δy_{max} of the soil samples as well as the soil samples' flexural rigidity (EI) and tensile strain. In Figure 7 snapshots of the non-contact digital imaging processing technique performed by the MATLAB code 2 is shown. In the processing, video data assigned to that particular soil sample was read by the algorithm. An image of the soil sample before testing is displays on the screen as shown in Figure 7, A. The user selects the region where the fracture occurs using a window shown by dotted lines in Figure 7A. Once selected, the algorithm processes the data of each frame captured in the video and maps the movement and deformation of the soil and thereby the fracture process. Figure 7, D is the final output. The algorithm is designed with a selection tool that then selects specific points as shown in Figure 7, D. Measurements that were taken included

i. Crack length (Figure 7, D: | b-a' |)
ii. Lengths of the crack boundary regions (Figure 7, D: |a-b|; | b-c|; | a-c|)
iii. Maximum deflection, Δy_{max} (see Figure 7, D: |b'-c' |)

All the measurements taken in Figure 7, D were in the digital domain and their units were in pixels. Hence, the information captured on the binary images (Figure 7, C) was used; the binary image of the known 6 mm diameter cylindrical tool acted as a reference point to convert all pixel measurements into SI units through the MATLAB code 2.

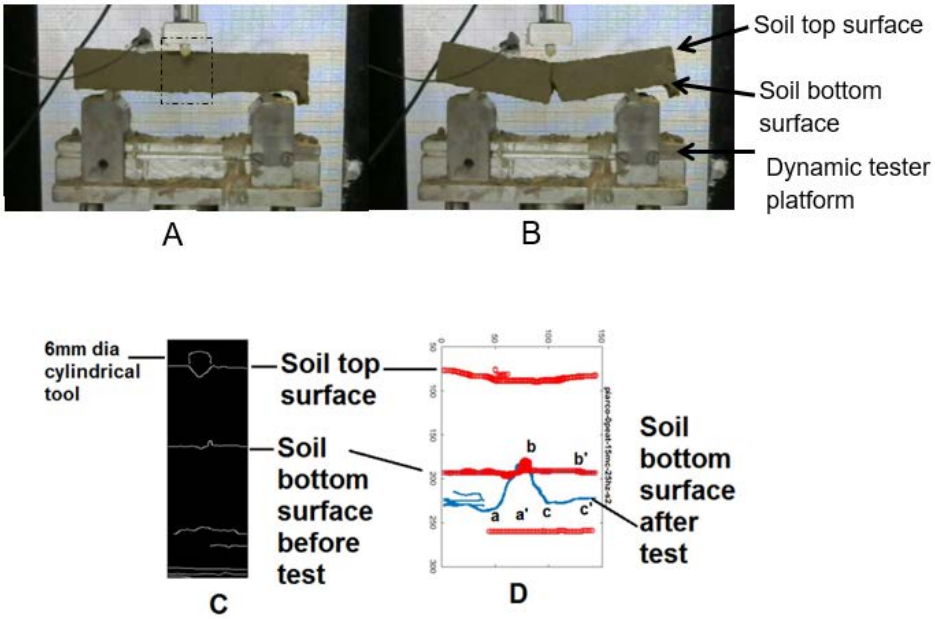


Figure 7: Image processing of soil sample Piarco-0 %peat, 15%mc. 10 Hz-sample #2. A: snapshot of soil sample before test. B: snapshot of sample at end of test. C: Binary Image before testing using MATLAB 'Canny algorithm'. D: Generated MATLAB Digital Image illustrating fracture and crack propagation process in soil sample

3. Results and Discussion

Table 1 and Table 2 show results on some of the soils samples that were processed by MATLAB code 1. Table 1 shows the values of time to failure, tensile strength, natural frequency and damping coefficient. Table 2 shows the values of energy in root mean square, peak and steady state energy terms.

Table 1: Mean[+] Values of Time of Failure, Natural frequency (ω), Damping coefficient (ζ) and Tensile Strength for Piarco Soil

% Peat Added	Water State	Freq-uency (Hz)	Dry Bulk Density (Mgm^{-3})	Time to failure (s)	ω (rad/s)	ζ	Tensile Strength (MPa)
0	15% less PL	10	1.39*	0.17	303.73	0.14	0.66
		50	1.30	0.31	276.12	0.15	0.84
		100	4.29	2.21	253.11	0.16	0.92
	10% less PL	10	1.31	0.21	477.07	0.13	0.24
		50	1.21	0.09	395.77	0.14	0.49
		100	1.36	0.25	256.17	0.17	0.32
	5% less PL	10	1.33	0.14	251.57	0.17	0.32
		50	1.28	0.39	559.90	0.07	0.18
		100	1.33	5.3	441.80	0.12	0.44
	PL	10	1.37	0.07	432.58	0.136	0.38
		50	1.38	0.42	461.73	0.09	0.07
		100	1.34	6.55	326.74	0.16	0.13

[+]Values are Partial Results after Processing by MATLAB Code-1.
PL refers to Plastic Limit, ω is the natural frequency of soil and ζ is the damping coefficient of the soil

Table 2: Mean[+] Values of Root mean Energy (RmsE), Peak Energy (PE) and Steady state energy (SsE) for Piarco soil and Talparo Soil

Peat Added (%)	Water State	Freq-uency (Hz)	Piarco			Talparo		
			RmsE $\times10^{-2}$ J	PE $\times10^{-2}$ J	SsE $\times10^{-2}$ J	RmsE $\times10^{-2}$ J	PE $\times10^{-2}$ J	SsE $\times10^{-2}$ J
0	15% less PL	10	1.1	2.6	0.2	3.6	5.6	0.5
		50	6.5	10.7	0.3	0.6	1.1	0.5
		100	5843.0	8162.0	12.4	1.30	1.80	0.6
	10% less PL	10	1.40	2.0	0.03	0.5	0.7	0.2
		50	0.9	1.7	0.6	1.0	1.8	388.0
		100	104.1	141.6	6.5	79.8	110	143.0
	5% less PL	10	0.2	0.4	0.2	1.0	1.8	0.1
		50	10.1	14.4	2.0	4.4	6.3	61.2
		100	550.6	938.3	9.4	4.8	7.0	1100.0
	PL	10	1.2	4.1	123.0	0.4	0.7	0.1
		50	7.6	10.8	20.0	0.1	0.3	4.3
		100	5476.2	7442.1	4.1	0.2	0.4	3.1

[+]Values are Partial Results after Processing by MATLAB Code-1.
PL refers to Plastic Limit, RmsE is the root means square Energy, PE is the peak energy and SsE is the steady state energy.

Table 3 shows the results of the processing of the video data and obtains information on crack length (CL), crack opening angle (COA), flexural rigidity and tensile strain (ε). Together all three tables characterize the behaviour of the two soil types under variations in peat content, consistency limit and frequency of tool movement. The factors: soil type, percentage peat and water states represent the initial conditions of the soil. The frequency of tool movement is controlled by the operator.

Table 3: Mean[+] Values of tensile strain (ε) crack length (CL), crack opening angle (COA) and flexural rigidity (EI) for Piarco soil

Peat Added (%)	Water State	Freq-uency (Hz)	ε (%)	CL (mm)	COA (rad)	EI kNmm^2
0	15% less PL	10	1.91*	18.84	0.26	1779.30
		50	1.88	19.41	0.27	1470.8
		100	2.59	19.86	0.86	9784.50
	10% less PL	10	2.25	20.66	0.19	419.00
		50	3.34	16.01	0.28	501.9
		100	1.51	19.23	0.24	272.90
	5% less PL	10	3.09	8.33	0.77	417.50
		50	1.31	5.86	1.38	814.40
		100	4.06	10.29	0.50	378.90
	PL	10	4.78	6.67	0.81	278.70
		50	1.69	1.81	1.98	282.1
		100	2.37	9.58	1.07	337.00

[+]Value are Partial Results after Processing by MATLAB Code-2
PL refers to Plastic Limit

The process being dynamic required instrumentation that captured mast information in the shortest time. Processing of this information is difficult if it were not for the algorithms written in MATLAB and existing software were not suited given the specific nature of the investigation. The two algorithms made processing of the data easier and complete. The next stage of the process would be an ANOVA on the data and then a complete statistical analysis. Figures 8 and 9 are interaction graphs and are two examples of the end result of the ANOVA and statistical analysis. In Figure 8 at 0% peat, Piarco had higher crack length than Talparo. Piarco is more susceptible to fracture than Talparo although Talparo deforms easier. The addition of peat reduces crack length in both soils between 4 and 8 % and these values converge when more peat is added. The values became near equal at 8% peat and increased slightly but remained the same thereafter. Generally crack length decreases for both soils (see Figure 9) as they approach their plastic limits. In Figure 9, Piarco has slightly higher values in crack length than Talparo but these values converge at the plastic limit. Information such as these are useful for soil scientist and engineers in fully comprehending the dynamic behaviour of soils.

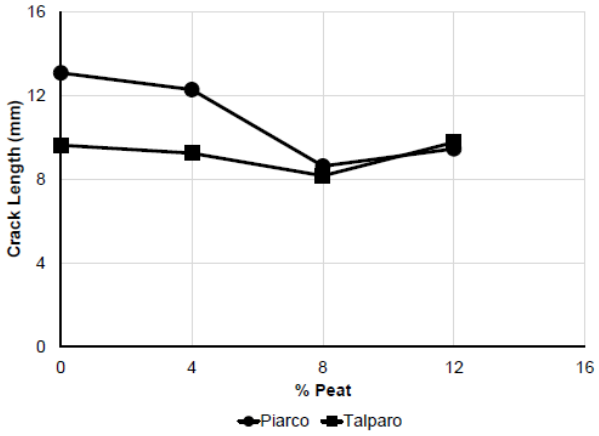


Figure 8: Plot of Crack Length against % Peat content for Two Soil Types

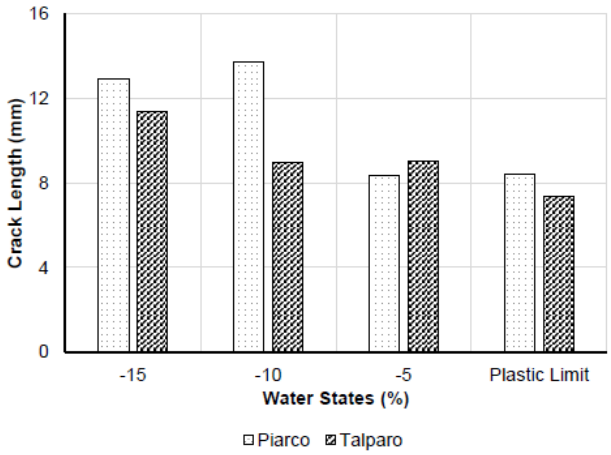


Figure 9: Plot of Crack Length against Water States for Two Soil Types

4. Conclusion

The two algorithms represented innovation in determining dynamic mechanical properties of soils using both contact and non-contact means. The use of these codes allowed massive data to be processed, analysed and interpreted effectively. Much information was obtained on the dynamic behaviour of soils. Without the availability of MATLAB, the progress of the research would have been slow and time consuming. The information is in a useful format that could be further analysed statistically. The end result is information that aids engineers in designing better implements for tillage or root harvesting applications.

References:

Aluko, O.B., and Chandler, H.W. (2006), "A fracture strength parameter for brittle agricultural soils", *Biosystems Engineering*, Vol.93, No.2, pp.245-252. https://doi.org//10.1016/j.biosystems.2005.11.007

Birch, R.A. (2018), The Characterisation of Tensile Fracture and Crack Propagation in Trinidad Soils with Varying Peat Content with Applications in Tillage, PhD Thesis (unpublished), The University of the West Indies, St. Augustine, Trinidad and Tobago.

Hallett, P.P., and Newson, T.A. (2005), "Describing soil crack formation using elastic-plastic fracture mechanics", *European Journal of Social Science*, Vol.56, No.1, pp.31-38. https://doi.org/10.111/J.1365-2389.2004.00652.x

Karmakar, S. (2005), *Numerical Modelling of Soil Flow and Pressure Distribution of a Simple Tillage Tool Using Computational Fluid Dynamics*, PhD Thesis (unpulished), University of Saskatchewan, Canada

Sumathi, S., and Surekha, P. (2007), *LabView based Advanced Instrumentation Systems*, Springer, New York

Wheeler, A.J. and Ganji, A.R. (2004), "Discrete sampling and analysis of time varying signals", In: *Introduction to Engineering Experimentation*, 2nd Edition, Pearson, New Jersey, p. 95-115

Authors' Biographical Notes:

Robert A. Birch *is an Instructor with the Department of Mechanical and Manufacturing Engineering at The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies. He has a BSc and MPhil in Agricultural Engineering and is currently a PhD candidate in Mechanical Engineering. Mr. Birch is a professional engineer (R.Eng) with more than 23 years industry experience and a member of the Institute of Agricultural Engineers, U K (MIAgrE). His research interests are in the design and development of machinery systems and Computer Aided Engineering (CAE)*

Jacqueline Bridge *is currently Senior Lecturer and Head of Department of Mechanical and Manufacturing Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies. Her research and teaching interests fall in the area of Applied Mechanics, with special emphasis on Mechanical Vibrations, Nonlinear Dynamical Systems Theory and Finite Element Methods.*

Edwin I. Ekwue *is currently Professor and Dean, Faculty of Engineering at The University of the West Indies (UWI), St Augustine, Trinidad and Tobago. He is also Coordinator of the Biosystems Engineering Programme and was a past Head of the Department of Mechanical and Manufacturing Engineering. His specialties are in Water Resources, Hydrology, Soil and Water Conservation and Irrigation and Drainage. His subsidiary areas of specialisation are Structures and Environment, Solid and Soil Mechanics, where he has teaching capabilities. Professor Ekwue has served as the Deputy Dean for Undergraduate Student Affairs and Post-graduate Affairs and Outreach, as the Chairman of Continuing Education Committee, and as the Manager of the Engineering Institute in the Faculty of Engineering at The UWI.*

■

The Potential Chemo-preventive Value of a Prenylated Flavonoid Isolate of Jackfruit

Isaac J. Morrison[1], JeAnn E. Murray[2], Roy Porter[3], and Rupika Delgoda[4]

[1] Faculty of Medical Sciences, The University of West Indies, Mona, Jamaica, West Indies; Emails: Isaac.morrison@mymona.uwi.edu;

[2,4] Natural Products Institute, The University of West Indies, Mona, Jamaica, West Indies; Emails: jeann.murray02@uwimona.edu.jm;thejani.delgoda@uwimona.edu.jm

[3] Faculty of Science and Technology, The University of West Indies, Mona, Jamaica, West Indies. Email: roy.porter@uwimona.edu.jm

Abstract: *AH0031, a prenylated flavonoid previously isolated from Artocarpus species, has been previously reported to possess cytotoxic properties towards prostate, breast and colorectal cancer cell lines, among others. Cytochrome P450 (CYP) enzymes are important catalysts in the metabolism of endogenous and exogenous chemicals. CYP1B1, a heme-thiolate monooxgenase, has been found to be over-expressed in hormone-mediated cancers such as prostate, breast and ovarian cancers where it is known to play an important role in cancer initiation, premalignant progression and tumour metabolism. Endogenous estrogens and xenobiotics including procarcinogens such as polycyclic aromatic hydrocarbons, aromatic and heterocyclic amines, found in smoked or charred meat and incomplete combustion of organic compounds, are activated by CYP1B1 to produce more reactive carcinogenic intermediates. The inhibitory impact of AH0031 on the catalytic activity of heterologously expressed human recombinant CYP1B1 microsomes (CYPEX ltd) was evaluated using a previously established, standardised fluorometric protocol and 7-ethoxyresorufin as the substrate. AH0031 inhibited recombinant CYP1B1 7-ethoxyresorufin- O-dealkylation activity in a concentration dependent manner (IC50 value: 1.00±0.01 µM). The inhibition of CYP1B1 was reversed by dialysis and no significant decrease in residual activity was seen when CYP1B1 was preincubated with NADPH prior to the initiation of substrate oxidation. Following preincubation with and without NADPH for 30 min prior to substrate oxidation, an IC50 shift vale of 1.04 was obtained, demonstrating that artocarpin was not a time dependent inhibitor of CYP1B1. Furthermore, artocarpin was found to inhibit CYP1B1 in non-competitive manner with a potent Ki value of 0.85±0.13 µM. Our results have demonstrated that AH0031 potently inhibits CYP1B1 in a reversible non-competitive manner and shows potential as a useful chemo-preventive and anti-cancer compound for cancers with an over-expression of CYP1B1.*

Keywords: *CYP1B1, 7-ethoxyresorufin, chemo-preventive, dialysis, IC50 shift, non-competitive*

Authors' Biographical Notes:

Isaac J. Morrison *is a Master of Philosophy student in the department of Basic Medical Sciences within the Faculty of Medical Sciences at the Mona campus of The University of the West Indies (UWI). His research interests include cytotoxic effects of plant extracts and compounds on cancer and normal cell lines and chemo-preventive properties of compounds and natural extracts. He has a BSc (Hons) Biotechnology and Chemistry degree from the University of the West Indies.*

JeAnn E. Murray *is JeAnn Watson is the Senior Scientific Officer of the Natural Products Institute, The University of the West Indies (UWI) Mona, where her primary research focus is evaluating the cytotoxic potential of natural and synthetic compounds and extracts against cancer and normal cell lines. Much of her research is also centered on the potential for drug interactions between clinical drugs and novel drug leads, natural compounds or extracts. She has an MPhil in Biochemistry and a BSc (Hons) in Biotechnology and Chemistry from the University of the West Indies.*

Roy Porter *is associated with the Faculty of Science and Technology, The University of West Indies, Mona, Jamaica, West Indies.*

Rupika Delgoda *is a tenured, Senior Lecturer in the Faculty of Science and Technology and the Director of the Natural Products Institute (NPI), at The University of the West Indies (UWI), Mona. Following a D.Phil. degree in*

Pharmacology at Oxford University, U.K. and a post-doctoral research Fellowship in Biochemistry at the University of Leicester, U.K., she commenced her research in Jamaica at UWI in 2002. Her current research interests surround ethnopharmacology, safety and efficacy of Jamaican natural products. With the support of local and overseas grant funds, Dr. Delgoda has established dedicated research facilities for identification of natural products with cancer prevention and treatment leads and evaluation of potential drug-herb interactions

■

Integrated Production of Biodiesel and Purified Glycerol from Waste Cooking Oil

Michael D. Coley[1], Denise D. Campbell[2], and Dale R. Rankine[3]

[1,2] Department of Chemistry, The University of the West Indies, Mona Campus, Kingston 7, Jamaica, West Indies;
E-mails: michael.coley@uwimona.edu.jm; denisecampbell2012@yahoo.com

[3] Department of Physics, The University of the West Indies, Mona Campus, Kingston 7, Jamaica, West Indies;
Email: dale.rankine@uwimona.edu.jm;

Abstract: *Used cooking oil is a widely produced waste stream from restaurants, fast food outlets and food companies that employ frying as a food preparation step. Jamaica produces approximately 30,000 metric tonnes of cooking oil annually but like most Caribbean islands, there is an absence of strong environmental regulations to ensure effective collection of the used cooking oil. As a consequence, it is often disposed of improperly into drains, sewer mains or on land. In this study, waste vegetable oil (WVO) from 20 restaurants across the Kingston Metropolitan Area (KMA), Jamaica, were tested to assess their suitability for producing petroleum-grade biodiesel and a method for purifying crude glycerol, the by-product generated alongside the biodiesel was also refined.*

Biodiesel is a sulphur-free, high-lubricity diesel fuel alternative that is environmentally friendly and can be blended with petroleum diesel and used to fuel diesel engines without any need for their modification. The WVO samples had free fatty acid (FFA) concentrations of 0.18 – 5.76% and over 80% were readily converted into biodiesel via base-catalysed transesterification using sodium hydroxide and methanol. Yields were typically ≥ 92% for oils with ≤ 1% FFA but reduced to about 86% for samples with ≥3% FFA. When used cooking oil with ≤2% FFA was processed on a pilot-scale in a 190L BioPro reactor, only three of the 19 measured parameters were inconsistent with the ASTM D6751 biodiesel standard. The crude glycerol by-product of biodiesel manufacture was processed via a modified acidification procedure using hydrochloric acid instead of the traditionally used phosphoric acid.

Both the crude and refined glycerol were characterised alongside commercial glycerol via infra-red spectroscopy, gas chromatography, gas chromatography-mass spectroscopy, nuclear magnetic resonance spectroscopy and metal ion analysis. The yield of refined glycerol was 47% and its purity was 99.08% which compares favourably in quality to commercial glycerol which is typically 97%. The analytical signature of the refined glycerol was also similar to that of commercial glycerol however it had a higher ash content. Samples of the refined glycerol were successfully incorporated into liquid soap, bar soap and hand sanitiser.

The work demonstrates that waste cooking oil from the KMA is a valuable resource that can be successfully converted into fuel-grade biodiesel and used as a blended fuel in diesel-powered motor vehicles. The crude glycerol by-product can be purified sufficiently to permit use as a raw material use in household and personal care products. Waste cooking oil is clearly a valuable feedstock with several applications. There is therefore need for an enlightened policy to stimulate structured collection and re-use of waste cooking oil and promote its processing into value-added products or conversion into energy.

Keywords: *Waste cooking oil; biodiesel; crude glycerol; purified glycerol*

Acknowledgements:

The authors wish to acknowledge the contributions of Edward Dixon, Jovan Johnson and members of Youth Crime Watch Jamaica to this work. We also acknowledge support from colleagues in the Departments of Chemistry and Physics, UWI, Mona. Finally, we recognize and thank the Global Environmental Facility Small Grants Programme and the University of the West Indies, Mona, for jointly funding the work.

References:

Chen, J., Yan, S., Zhang, X., Tyagi, D., Surampalli, Y., and Valero, J. R. (2018), "Chemical and biological conversion of crude glycerol derived from waste cooking oil to biodiesel", *Waste Management*, Vol.71, pp.164-175.

Chhetri, A., Watts, K.., and Islam, M. (2008), "Waste cooking oil as an alternate feedstock for biodiesel production", *Energies*, Vol.1, pp.3-18.

Nanda. M. R., Yuan, Z., Qin, W., Poirier, MA. and Chunboa, X. (2014), "Purification of crude glycerol using acidification: Effects of acid types and product Characterisation", *Austin Chemical Engineering*, Vol.1, pp.104-107.

Tan, H.W., Abdul Aziz, A.R., and Aroua, M.K. (2013), "Glycerol production and its applications as a raw material: A review", *Renewable and Sustainable Energy Reviews*, Vol.27, pp.118-127.

Authors' Biographical Notes:

Michael D. Coley *is a lecturer at the Department of Chemistry, University of the West Indies, Mona where he teaches Applied, Industrial and Analytical Chemistry. His research focus areas include : Bayer Process Technology, Bioenergy, Sustainable Waste Management and Waste Re-use. He has keen interest in research that promotes environmental sustainability and the creative use of waste resources.*

Denise D. Campbell *is a certified Food Quality Professional. She holds a BSc degree with majors in Food Chemistry and General Chemistry from the University of the West Indies, Mona and is in the final stages of completing the MSc in Food and Agro- processing Technologies. She is keenly interested in research that converts food waste into high value products that have strong business potential.*

Dale R. Rankine *is an adjunct lecturer at the Department of Physics, University of the West Indies, Mona and lead researcher in the application of Climate Modelling to Research in Agriculture. Through Crop Simulation Modelling, Dr Rankine provides a route for exploring the performance of crops in a variety of climatic conditions. He is also keenly involved in alternative energy research, environmental management and waste re-use.*

■

Flood Management in Informal Settlements: The Case of Les Cayes, Haiti

Wisly Jean-Claude[1] and Asad Mohammed[2]

Department of Geomatics Engineering and Land Management, Faculty of Engineering, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies;
[1]Email: wisly.jeanclaude@gmail.com;
[2]Email: asad.mohammed@sta.uwi.edu;

Abstract: *Flooding in Haiti is an issue of dire concern, due to its devasting impact on the country and its inhabitants. This research applies both quantitative and qualitative approaches to investigate the causes of flooding in the city of Les Cayes, Haiti and the living conditions of the inhabitants, in order to recommend sustainable solutions. Thirty-four (34) informal settlements, located in the wetlands, mangroves, mouths of rivers and the coastline were selected using a rapid sampling technique. A thorough examination of existing literature, site visits, and a survey utilising spatial analysis were conducted. The data was then analysed by using the software InfoStat and Excel, and basic mathematic calculus to ascertain trends and pertinent concerns. It was found that major causes of the flooding problem were the clogging of concrete gutters and scuppers and difficulty in evacuating rain water because of obstructions due to waste; degradation of the watershed; and rising sea levels. Settlements that were affected by floods were those which developed with irregular urban patterns and those located near the rivers and the coastlines. A high percentage of these, were characterised by difficult living conditions. The findings indicated that the highest priority needs of the informal settlements were engineering strategies and an urban planning redevelopment strategy, incorporating flood mitigation.*

Keywords: *Flood, Informal Settlements, Les Cayes, Drainage, Watershed, Urbanisation*

1. Introduction

The impacts and events of recent floods have been unprecedented and have affected the lives of millions of people around the world. These impacts have been shared by countries with rapid urban expansion in several areas that are prone to flooding. Concerns about floods and associated human impacts are clearly of global importance, especially when linked to fears of climate change and associated changes in rainfall and sea-level rise (Kundzewicz et al., 2014). Furthermore, the rapidly expanding urban environments in many regions reflect a lack of urban planning strategies, lack of capacity and deterioration in urban drainage infrastructure, and a rate of developmental floodplain development (Gill 2004,. CII, 2001).

For decades, flooding has been one of the catastrophic problems globally, which has resulted in significant loss. The growth in the urban areas of most Caribbean countries "Small Island Developing States", is the result of unplanned urban extensions. The low level of awareness and the limited factors to reduce the promptness of these developments, are the factors contributing to the vulnerability of their inhabitants. Lack of institutional capacity to control urban development, and economic incapacity to meet the need for a dense population living on small islands.

Additionally, small size has many disadvantages, including a high population density, which increases pressure on already limited resources; excessive use of resources and their premature decline; costly administration and public infrastructure; and limited institutional capacity. Because of their small size, and their isolation from major world markets, their economic vulnerability exceeds national control (Boto and Biasca, 2012).

Haiti is considered one of the most vulnerable countries in the world to natural disasters. Over the past decades, Haiti's vulnerability has been aggravated by the rapid increase in the rate of urbanisation, the interaction between population pressure and massive migration to urban centers, environmental degradation through deforestation, poor watershed management, and poverty. The vulnerability of urban areas to flooding has increased following migration to these areas, in particular Les Cayes[1].

The increase in the quantity of water flowing in the rivers affect the entire bed, the water exceeds the usual height with a great speed of the current and the flood can last for days, even weeks. The height of the submersion has a significant impact on the city, especially when it exceeds the limit of the usual flow. The supporting structure of some houses are damaged, the floors and walls are filled with water and through the drainage channels, and rainwater overflows on the sidewalks of the streets. The most vulnerable areas are the informal settlements. This can result in drowning due to overflowing rivers and residents being exposed to health risk after each flood.

[1] Les Cayes is the city where the research was carrying out and the inhabitants name Cayen.

This research aims to examine these problems by using an analysis and synthesis of available historical data on floods in the Les Cayes region of Haiti. This study also reviews the circumstance and awareness of riverine risks and help with the management of these events. This research is to develop a conceptual and methodological approach to the problem of flooding, specifically through a study of informal settlements which is the primary objective and a study of the drainage channel, and the southwest watershed, which are secondary objectives. After this contextualisation, the evaluation methodology applied in this study is explained.

2. Literature Review

Figure 1 shows a framework that was adopted by Nkwunonwo et al. (2016), to explain the causes of the floods based on research conducted in Lagos, West Africa, the south-western part Nigeria. The main causes of flooding in this urban environment are related to global climate change, poor urban planning, urbanisation, and human activities. In Lagos, Flooding and flood management are issues of grave significance (Aderogba, 2012a, b). From previous studies (for example, Ajibade et al. 2013, 2014; Adelekan, 2013), flooding in the area can be devastating, affecting hundreds of thousands of people, and causing considerable economic damage.

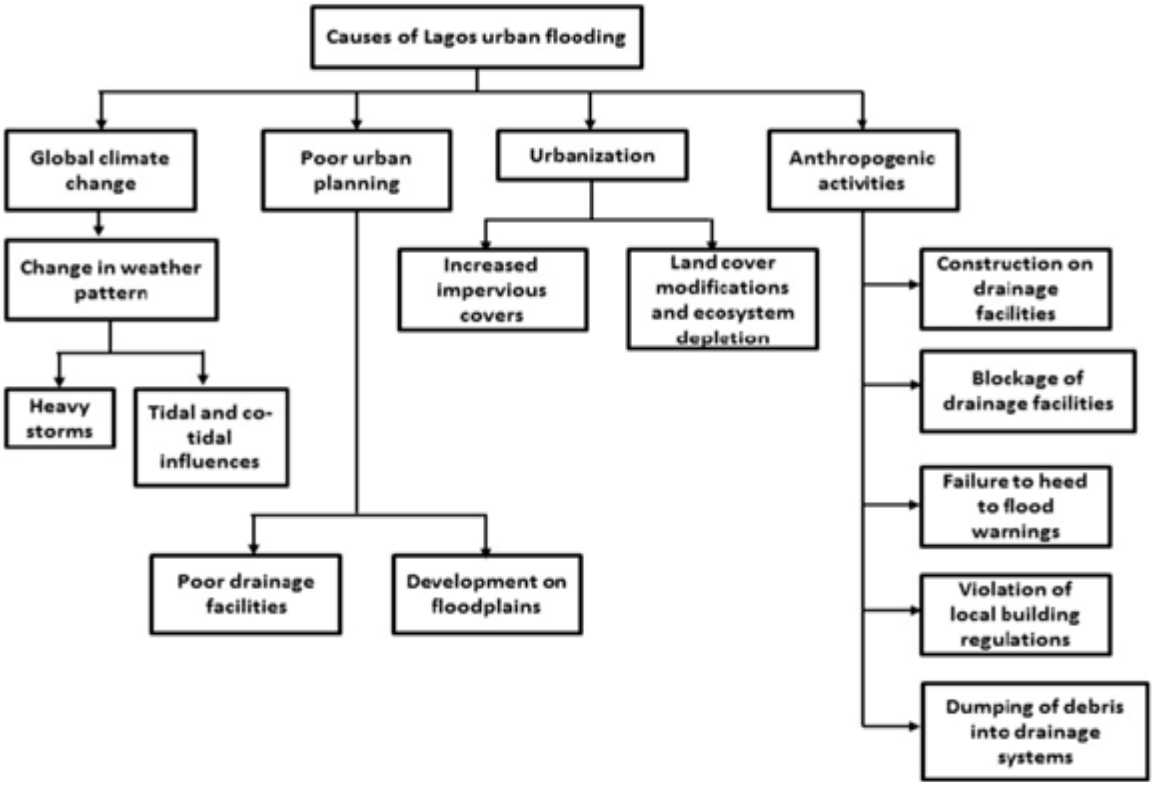


Figure 1. Causes of the urban flooding in Lagos
Sources: Nkwunonwo et. al. (2016)

The flood hazards mitigation plan for the state of Nebraska in 2013, adopts two comprehensive measures which are: Structural and Non-structural measures. Structural mitigation measures include but is not limited to: levees, dams, floodwalls, jetties, retention ponds, bridges and culverts, and many other examples. Structural mitigation projects aim to divert water away from people and Informal Settlements.

Non-Structural Mitigation is a strategic land use planning tool that identifies the extent of flood that impacts the land and seeks to limit the construction of urban and rural residential, commercial, and industrial land uses. Another Non-Structural measure is conducting property surveys in vulnerable settlements, this involves a detailed study of homes affected by floods that can help to increase the accuracy of flood modelling so that homeowners can understand the real impact of flooding on each property.

3. Methodological Approach

Various scholarly articles were perused, reviewed, and compiled in a literature review with regards to understanding the causes of floods through work that was done globally. The precedent Lagos framework has been found to be most appropriate and has been selected to conduct the investigation of the flood problem of Les Cayes. The research was focus on three main (3) key elements that were identified and selected for carrying out the survey, which are the **informal settlements**, the **drainage network**, and the **southwest watershed**.

The survey in the settlements utilised spatial analysis/GIS and site visits to identify informal settlements, their boundaries and their urban pattern. A questionnaire was administered to examine the living conditions and a community focus group was organised to allow interaction with residents and to obtain further information.

Spatial analysis /GIS and site visit were the approaches used to attain data on the drainage channels, and on the watershed, respectively. Existing documents were sourced from various governmental and, non-governmental organisations, and private sector departments. The data was collected and analysed to determine any trends or significant considerations.

Additionally, interviews were conducted with the management of those facilities and, community spokesmen, to gain more information about the situation in the area and any impacts that it may have had on the physical environment. Private sector representatives and government officials were consulted to obtain expert perspectives regarding the information and plans in addition to their experiences of the development in the area. These ministries can provide statistical data and credible records regarding the historical background of the area. The final process of the research method is a review of all data collected and the analysis by different stakeholders.

The data collection methods applied in the project allowed the researcher to access a wide array of information based on different perspectives. In addition, to the information concerning flooding around Les Cayes city, the researcher, sought to understand, what accounted for the high levels of persistent flooding and how this issue could be solved.

4. Results

This paper presents the results of the analysis, of the informal settlements, the drainage channels, and the watershed, on the actual situation and on the institutional framework. This overview provides an understanding of the issue, especially informal settlements / slums with the most difficult living conditions. In this analysis, the data from 34 informal settlements, including the two (2) informal settlements located outside the administrative boundaries of the city were used.

4.1. Settlement demographic and Land Occupation analysis

The total number of buildings in the informal settlements within the administrative boundary of the city is 4,699 compared to the total number of 15,185 buildings in the city (see Figure 2). The proportion of buildings located in informal settlements represents 31% of the total building of the city, 65% of the city's residents live in informal settlements, where almost one (1) in three (3) Cayens is a "squatter" (see Figure 3).

Of the total city area of 898 ha (administrative boundary, according to IHSI), 97ha are occupied by informal settlements. This means that informal settlements occupy less than 11% of the city's area while housing occupies 31% of the city's buildings. This is a good indicator of the highest urban density in these settlements compared to other areas of the city. Proportionally, the informal settlements of Les Cayes absorb a large urban population compared to other areas of the city.

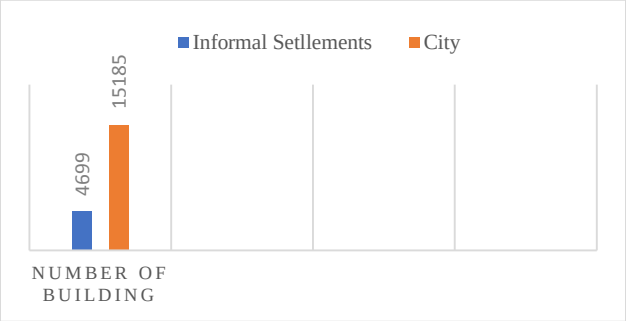


Figure 2. Informal Settlements and No. of Buildings

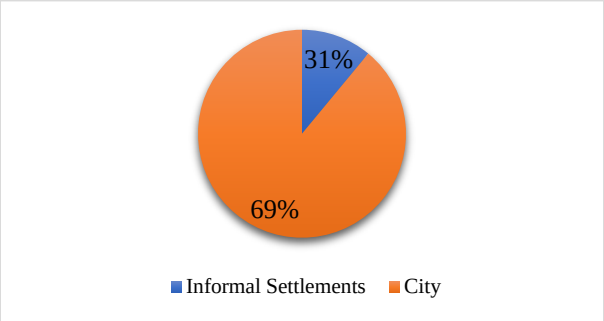


Figure 3. The proportion of buildings

Figure 4 is a map showing the urban area of Les Cayes city, the living conditions of the informal settlements and buildings representation

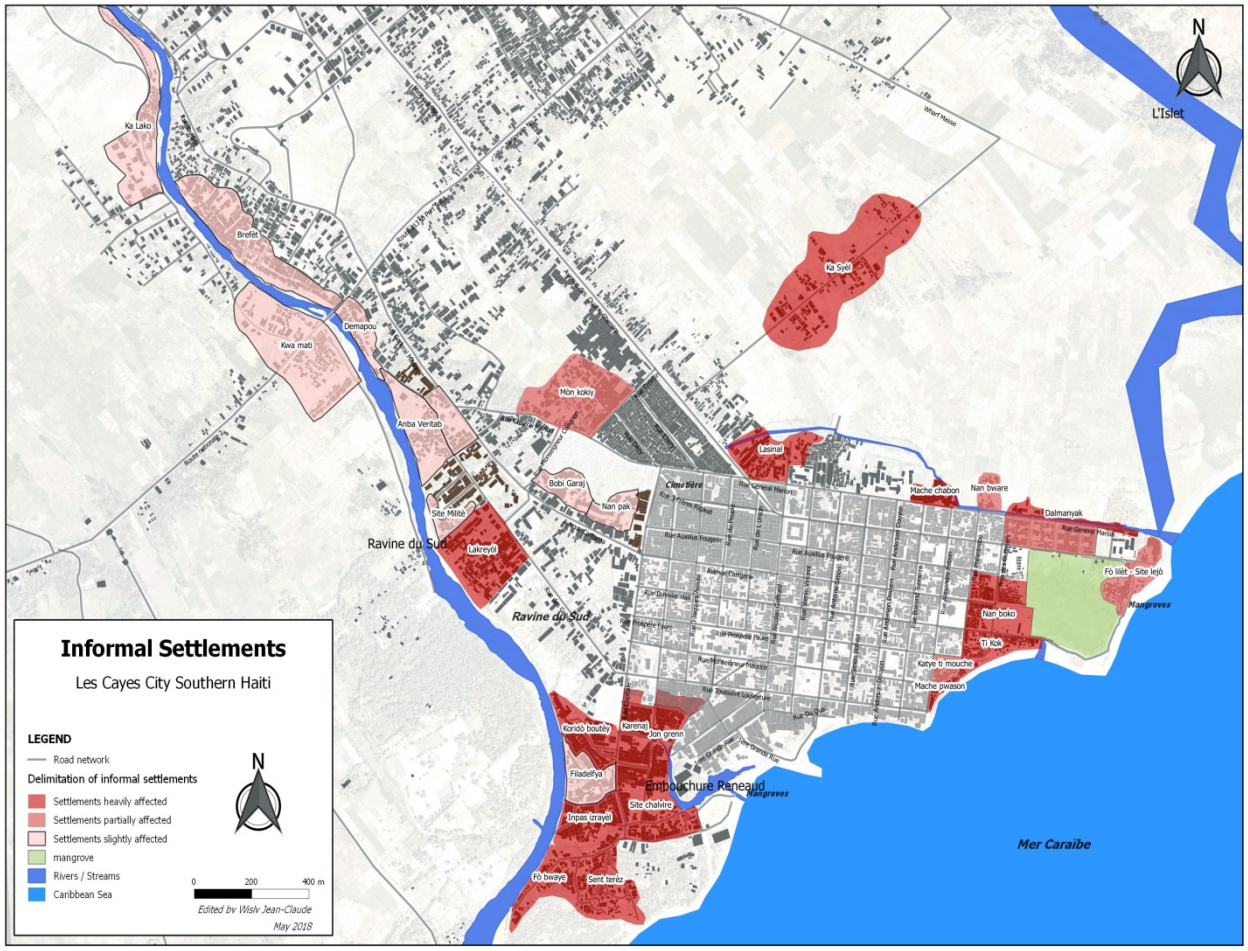


Figure 4. A map represents the urban area of Les Cayes city

4.2. Settlements Patterns and Settlement Conditions Analysis

According to Lynch (1981, 48), settlement form includes both the spatial arrangement of acting people, and the spatial flows resulting from that, plus the physical features modifying space. Physical planning in these settlement does not respect the urban development norms, due to lack of planning or construction and illegal without a specific order.

Regarding the planning aspect, only 30% of the city's buildings (administrative limit) are built on a regular pattern. It is mainly the colonial city in "grid pattern". Some immediate extensions of the city center have a semi-regular pattern (6%). All other sectors (extension) of the city are unplanned, with an irregular urban pattern (64%). None of the urban extension areas beyond the administrative boundaries of the city is planned. If the city defines as "built space", then it is found that more than 2/3 of the city of Les Cayes are not planned.

Unplanned settlements ("informal settlements"), with absent slum characteristics, are rapidly becoming denser. This alarming trend is likely to produce new slums around existing informal settlements. Living conditions in fifteen (15) informal settlements are "very difficult" (see Table 1). They were assessed as less than 40% of the state of a properly developed settlement. Sixteen (16) informal settlements, or almost half of them, are characterised by a "difficult" living environment: between 40% and 60% of the adequacy criteria are fulfilled. Only three (3) informal settlements are nearing adequately equipped settlements with more than 60% of fit criteria met.

Table 1. Informal settlements living conditions

Difficulty of living conditions	Evaluation categories	Numbers of informal settlements	Percentage of Informal settlements
Very difficult	0-39% adequate	15	44%
Difficult	40-59% adequate	16	47%
Relatively easy	More than 60% adequate	3	9%
TOTAL		34	100%

The analysis shows that seven (7) of the fifteen (15) informal settlements with the most difficult living environment, are located in La Savane[2]. Of the eleven (11) informal settlements in La Savane, seven (7) are among the most precarious in terms of living conditions and vulnerability to natural disasters. It is therefore finding that informal settlements concentrated in La Savane are the furthest from being well-developed settlements with sustainable housing that offers enough living space, poorly equipped to withstand the impacts of floods and secure land tenure.

4.3. Evacuation of Wastewater, Rainwater and Weaknesses of the Drainage System

The percentage of houses in informal settlements affected by wastewater and rainwater is an indicator for the absence or dysfunction of the drainage network, a key component of the sanitation system. The result of the analysis shows that seven (7) of the informal settlements are moderately affected by stagnant water. In seventeen (17) informal settlements, between 60% and 100% of houses are exposed to the problem of water that does not drain properly. Only in 10 informal settlements the waters are drained without considerable difficulty. Table 2 shows a summary of the evaluation of settlements affected by water. Moreover, as depicted in the map of Les Cayes city (see Figure 2), settlements that suffer the most from drainage water are: Settlements located upon the drainage channels; Settlements concentrated in the mouth of streams and rivers; settlements located around the marshes; and those located in the outlet of the drainage channels on the coastline.

Table 2. Evaluation of settlements affected by water

Percentage of houses affected by water	Numbers of Informal settlements	Percentage of Informal settlements	Evaluation
60 and more	17	50%	Heavily affected
Between 20 and 59	7	21%	Moderately affected
Less than 20	10	29%	Slightly affected
TOTAL	34	100%	

The common reason for the prevalence of stagnant water in all these settlements is the lack, or inadequacy of the drainage network. Roads, and the various networks not having been installed in the unplanned urban extensions where most informal settlements are located, the waters do not flow in streets in poorly levelled dirt or hand-dug trenches, and with contradictory slopes. In the case of settlements located in the mouths of rivers and ditches, they are not properly canalised. In many places, anarchic constructions and solid wastes block the drainage.

4.4 Watershed Analysis

Environmental health is significantly poor today. This is mainly linked to the massive deforestation of the entire territory, with a major impact on the health of watersheds. In 2000, 97% of the territory was deforested (CIAT, 2010). The deforestation and the degradation of the vegetation cover are linked to the strong land pressure to the increase of the population and to the needs of fuel, such as wood and charcoal. The Haitian territory is composed mainly of mountains and most of the land is on slopes (63% of the area consists of slopes superior than 20%). Considering the characteristic of a slope of 20%, according to both, the reality of the Haitian territory, the horizontal distance of one hundred (100) m and the height of twenty (20) m, the result obtained (R) is 101.98m for the length of the slope, Angle of the slope is 11.31 °, and the complementary angle is 78.69 °. The degradation of soils in the mountains is facilitated and erosion is a daily phenomenon.

[2] The largest area in the city of Les Cayes names La Savane where contain the most vulnerable informal settlements.

Upstream, the problem of deforestation causes erosion in the mountains, the increase of the solid flow caused by the continuation of erosion. Erosion of riverbanks and embankments is due to the following reasons: poor construction or inadequate maintenance of rivers and streams. The direct consequences of slope erosion are, among other factors, the loss of arable land. In addition to direct damage, caused by sediment transport and deposition; this includes silting of streams and rivers, sedimentation in reservoirs and nesting sites.

5. Discussion

Integrating the flood mitigation strategy into a broader plan for the entire urban area of the city is particularly important for reducing risks in informal settlements. They require an urban redevelopment planning strategy as well as structural and non-structural interventions targeting the whole city, such as housing development and relocation in term of durability of housing and improvement of living conditions; expansion of the drainage and road network; solid waste management; and the protection of settlements against natural hydrological hazards.

The mandate institutions should involve in the strategy of urban planning initiatives, and the capacity to enforce the law in the development of anarchic settlements in vulnerable areas. This should have a dampening effect on urban sprawl. The creation of additional housing, either for the families of the owners themselves, or for the rental market, should contribute to reducing the current promiscuity in informal settlements.

6. Conclusion

This in-depth research of the flood situation in the informal settlements in Les Cayes, leads to conclusions that require rapid and sustainable interventions. The highest priority need of informal settlements, is an urban planning redevelopment strategy, additionally a structural and non-structural mitigation for the entire city. This is including the improvements in the areas of roads and drainage, protection of settlements against overflowing rivers and rising sea, and solid waste and housing management in line with international rules.

References:

Boto, I. and Biasca, R. (2012), PEID: *Des vulnérabilités aux opportunités*, Office of CTA, Bruxelles, September.

CIAT (2010), *La gestion intégrée des bassins versants*, Comité Interministériel d'Aménagement du Territoire Port au Prince, Haïti, December

CIAT (2013), *Law and Regulation of Urbanism*, 1st Edition, July, Comité Interministériel d'Aménagement du Territoire, Port-au-Prince, available from http://www.ciat.gouv.ht/ Accessed 6 February 2018

GFDRR (2014), *Inondation Urbaine*, UNDP, UE, Sénégal, July.

H-J. Scarwell et M. Franchomme, (2004), "Contraintes environnementales et gouvernance des territoires de Lille ", In : Alexandre Brun et Frederic Lasserre (Ed), *La politique de l'eau*, Presses de l'Université du Québec, Québec, p.175-180

IADB (2013), *Flood Alleviation and Drainage Program TT-L1036* Inter-American Development Bank, Port of Spain, Trindad and Tobago, August

IKSR, CIPR, ICBR (2015), *Plan de gestion District Hydrologique International Rhin*, Europe France, December.

INRS-ETE (2011), *Adaptation aux changements climatiques en matière de drainage urbain*, Québec, Canada, December

Kevers, E. (2004), "Réflexion sur la cartographie des zone inondation, PLUIES plan", In: *La politique de l'eau,* edited by Alexandre Brun et Frederic Lasserre, p.175-180. Québec : Presses de l'Université du Québec.

Lynch, K. (1960), *The Image of the City*, MIT Press, Cambridge MA, p.194

Lynch, K. (1981), *A Theory of Good City Form*, MIT Press, Cambridge MA. P.117, 265, 514

MENFP (2011), *Evaluations des besoins post cyclone*, secteur éducation, South, Haiti, November

NEBRASKA (2013), *Flood Hazard Mitigation Plan for the State of Nebraska*. Department of Natural Resources, Available from https://dnr.nebraska.gov/floodplain/flood-mitigation, accessed 12 February 2018.

Nelson, S.A. (2016), *River Systems and Causes of Flooding*. Tulane University, New Orleans, October

New Urban Agenda (2016). *United Nations Conference on Housing and Sustainable Urban Development*, Habitat III-Quito, October

Nkwunonwo, U.C., Whitworth, M., and Baily, B. (2016). *A Critical Review of Lagos Urban Flood Risk Management.* Nigeria, February

Tas, M., Tas, N., Durak, S., and Atanur, G. (2013), "Flood disaster vulnerability in informal settlements in Bursa", *Environment and Urbanisation*, Vol.25 No.2,, September, Turkey.

Udika, R. (2010), "Flood management: An examination of mitigation measures for flooding", *Proceedings of the 46th ISOCARP Congress*, Trinidad and Tobago.

UN-Habitat (2015), *Diagnostic Urbain de la Ville des Cayes*, Analyse du cadre institutionnel, politique et réglementaire pour l'amélioration Urbain. Les Cayes, PSUP Participatory Slums Upgrading Programme

UN-Habitat, (2016), *Support to Sustainable Urban Development in Kenya*, Addressing Urban Informality Volume 4: Report on Capacity Building for Community Leaders. United Nations Human Settlements Programme, Kenya

World Bank (2016), *Situation économique*. Haiti, October. Available from http://www.banquemondiale.org/fr/country/haiti/overview Accessed 05 June 2018

Authors' Biographical Notes:

Wisly Jean-Claude *is a civil engineer, cartographer and in the final stage of an MSc in Urban and Regional Planning at the University of the West Indies, St. Augustine Campus. He is a member of the Technical Local Team of the Participatory Slum Upgrading Program (PSUP) in Les Cayes Haiti. His research interests are in the area of civil construction, cartography, and urban and regional planning.*

Asad Mohammed *is Coordinator of the Graduate Programme in Urban and Regional Planning, at The University of the West Indies, St. Augustine, which he helped establish in 1994. He has been an advisor and consultant to many Caribbean governments and multilateral agencies in the region working on planning, land and housing matters.*

■

Africanized Bees - The Bees of the Future

Jo-Anne N. Sewlal[1], Ricardo G. D'Andrade[2]; Hayden A. Sinanan[3], and Gordon P. Deane[4]

[1] Caribbean Academy of Sciences, c/o Faculty of Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies; Email: joannesewlal@gmail.com;

[2] No.10 Plumrose Ave, Santa Rosa Heights, Arima, Trinidad & Tobago, West Indies; Email: rickygdan@yahoo.com;

[3] Ministry of Agriculture Land and Fisheries, St. George West County Extension Office, Farm Road, Curepe, Trinidad and Tobago, West Indies; Email: haydensinanan@gmail.com;

[4] Perseverence Estate, Maraval, Trinidad and Tobago, West Indies; Email: gpdeane@hotmail.com;

Abstract: *The mention of "Africanized bees" strikes fear in many people including beekeepers. The Africanized bee (Apis mellifera scutellata) is a sub-species of the docile European honey bee (Apis mellifera). The increased defensive nature displayed by this sub-species adds difficulty in handling them, and has led many beekeepers taking extreme measures to prevent their spread. In the Caribbean, this sub-species is currently found in Trinidad and Puerto Rico. The benefits of Africanization of the bee populations in the Caribbean include disease prevention particularly from the Varroa Mite (Varroa destructor), which carries a multitude of pathogens. Thus, preventing the use of chemicals such as miticides and antibiotics, saving beekeepers money, as well as and preserving the quality of the honey produced. Their adaptability to the tropical climate has resulted in improved honey production compared to European bees. Also, intentional and unintentional selective breeding by local beekeepers have resulted in populations of more docile populations which make for safer handling of this sub-species.*

Keywords: *Africanized bees, Apis mellifera scutellata, Caribbean, tropics, Varroa destructor*

Authors' Biographical Notes:

Jo-Anne N. Sewlal *is a scientist and holds BSc, MPhil, and PhD. from The University of the West Indies, St. Augustine. Her specializations include arachnology and entomology. She is the author of 50 scientific publications (including various hymenopteran groups such as, wasps, stingless bees and ants) and 700 general publications in the areas of biodiversity, ecology and the environment. She has been quoted in articles for National Geographic and Livescience. Some of her awards include being the first female, postgraduate and youngest recipient of the CAS-TWAS Young Scientist Award and Frank Rampersad Junior Scientist from NIHERST.*

Ricardo G. *D'Andrade is a commercial Beekeeper for the past thirty-five years. After graduating from the University of the West Indies with a BSc. in Natural Sciences, he did a brief stint at teaching before taking the bold step of going into Beekeeping full-time. He has travelled to many South American countries working with and studying Africanized bees. He is an executive member of the Trinidad and Tobago Beekeepers Association, where he plays a role in educating and mentoring beekeepers. His main objective is to promote sustainable beekeeping and to see the industry flourish in Trinidad and Tobago.*

Hayden A. Sinanan *is the Inspector of Apiaries for Trinidad and Tobago. He holds a Diploma in Agriculture from the Eastern Caribbean Institute of Agriculture and Forestry. He has 24 years of experience in Beekeeping Extension and Consultancies, (local and regional). He conducts training of new and existing Beekeepers in all areas of Africanized Bee Management and private and state agencies in bee abatement services. He also advises new and existing small, medium and large-scale beekeepers in Africanized Honey Bee management practices throughout Trinidad and Tobago.*

Gordon P. Deane *is currently the Chairman of the Atlantic LNG Company of Trinidad and Tobago Limited. He also serves as Deputy Chairman of Pan American Life Insurance Company (Trinidad and Tobago Limited) and Chairman of its Audit Committee. He has 15 years in the bee-keeping industry. During the past two years he decided to explore the scientific aspect of bee-keeping and develop his commercial apicultural endeavours. He founded the "Bee News" newsletter on the subject of bee-keeping in Trinidad and Tobago, aimed at both the bee-keeping community and the consumers.* ■

Food Fraud - Honey Laundering

Jo-Anne N. Sewlal[1], Ricardo G. D'Andrade[2]; Hayden A. Sinanan[3], and Gordon P. Deane[4]

[1] Caribbean Academy of Sciences, c/o Faculty of Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies; Email: joannesewlal@gmail.com;

[2] No.10 Plumrose Ave, Santa Rosa Heights, Arima, Trinidad and Tobago, West Indies; Email: rickygdan@yahoo.com;

[3] Ministry of Agriculture Land and Fisheries, St. George West County Extension Office, Farm Road, Curepe, Trinidad and Tobago, West Indies; Email: haydensinanan@gmail.com;

[4] Perseverence Estate, Maraval, Trinidad and Tobago, West Indies; Email: gpdeane@hotmail.com;

Abstract: *Food laundering is a serious problem arising out of the demand to feed a growing global population and the honey industry has fallen victim to this fraud. Most of the Caribbean islands can supply their local demand with the exception of Jamaica which produces enough to export. Local legislation prevents the importation of honey due to the possible contamination with pathogens. However, cheap adulterated honey still makes its way to consumers. This makes it especially difficult for small scale beekeepers to compete. Most of the laundered honey comes from Asia. Mass production affects the quality of the honey and also acts as a source of pathogens. Adulterated honey also contains residues of chemicals such as, pesticides, heavy metals and antibiotics which can affect the health of the consumer. However, in the Caribbean honey is not only for culinary purposes but there is a sector of the population that uses honey for religious purposes. Fake honey is often produced by creating a mixture of fructose sugars like corn or rice syrup and adding artificial flavourings or a little genuine honey. To avoid detection, honey launderers use techniques such as microfiltration to remove the pollen from honey, thus obscuring its geographic origin. Fake honey is also shipped to other countries where it is relabelled and sold. We include some simple tests and important label information which will help consumers in identifying adulterated honey. Honey laundering highlights the need for a regional testing facility.*

Keywords: *Food laundering, Caribbean, adulterated honey, pesticide residues, heavy metals*

Authors' Biographical Notes:

Jo-Anne N. Sewlal *is a scientist and holds BSc, MPhil, and PhD. from The University of the West Indies, St. Augustine. Her specializations include arachnology and entomology. She is the author of 50 scientific publications (including various hymenopteran groups such as, wasps, stingless bees and ants) and 700 general publications in the areas of biodiversity, ecology and the environment. She has been quoted in articles for National Geographic and Livescience. Some of her awards include being the first female, postgraduate and youngest recipient of the CAS-TWAS Young Scientist Award and Frank Rampersad Junior Scientist from NIHERST.*

Ricardo G. *D'Andrade is a commercial Beekeeper for the past thirty-five years. After graduating from the University of the West Indies with a BSc. in Natural Sciences, he did a brief stint at teaching before taking the bold step of going into Beekeeping full-time. He has travelled to many South American countries working with and studying Africanized bees. He is an executive member of the Trinidad and Tobago Beekeepers Association, where he plays a role in educating and mentoring beekeepers. His main objective is to promote sustainable beekeeping and to see the industry flourish in Trinidad and Tobago.*

Hayden A. Sinanan *is the Inspector of Apiaries for Trinidad and Tobago. He holds a Diploma in Agriculture from the Eastern Caribbean Institute of Agriculture and Forestry. He has 24 years of experience in Beekeeping Extension and Consultancies, (local and regional). He conducts training of new and existing Beekeepers in all areas of Africanized Bee Management and private and state agencies in bee abatement services. He also advises new and existing small, medium and large-scale beekeepers in Africanized Honey Bee management practices throughout Trinidad and Tobago.*

Gordon P. Deane *is currently the Chairman of the Atlantic LNG Company of Trinidad and Tobago Limited. He also serves as Deputy Chairman of Pan American Life Insurance Company (Trinidad and Tobago Limited) and Chairman of its Audit Committee. He has 15 years in the bee-keeping industry. During the past two years he decided*

to explore the scientific aspect of bee-keeping and develop his commercial apicultural endeavours. He founded the "Bee News" newsletter on the subject of bee-keeping in Trinidad and Tobago, aimed at both the bee-keeping community and the consumers.

■

MHealth Disease Surveillance and Monitoring Among the Jamaican Diabetic Community: A Cross-sectional Study of the Interest to Use Health Mobile Apps

Susan A. Muir

Faculty of Engineering and Computing, University of Technology, Jamaica, West Indies; Email: smuir@utech.edu.jm;

Abstract: *Effective computer-based surveillance systems of non-communicable diseases may reduce the occurrence of chronic diseases such as diabetes. Jamaica has a high smart phone penetration rate; there is an opportunity for m-health surveillance and monitoring through patient self-reporting. The study investigated the extent to which the Jamaican diabetic community (patients living with Type 2 diabetes, healthcare professionals, and public health administrators) are willing to use MHealth (a mobile app for monitoring and surveillance of diabetes, MAMAS-Diabetes), as well as the factors that are associated with the willingness of diabetic patients to use this tool. The study involved a cross-sectional study of 100 persons living with diabetes in Kingston, St. Andrew and St. Catherine, Jamaica. Semi-structured interviews were conducted with four healthcare professionals and one Medical Officer of Health to record their interest in MAMAS-Diabetes as well as to provide feedback about the mobile app prototype. This study suggests that there is a strong level of interest in MAMAS-Diabetes among healthcare professionals and adult Jamaicans living with type 2 diabetes (T2DM). Most T2DM patients are willing to share health data (e.g. over 90% in the sample are willing to share blood sugar and blood pressure readings); not surprisingly, there is a greater reluctance to share their geographic location (70% of patients are willing to share location with the MOH). The most desired features of MAMAS-Diabetes include dietary or exercise suggestions, medical care suggestions, and appointment scheduling/ reminders. The factors linked with the acceptance of MHealth by T2DM patients for reporting health data include performance expectancy ($r = .928$, $p < .01$), social influence ($r = .804$, $p < .01$), and health belief and concerns ($r = .513$, $p < .01$). Policy makers should implement computer-based disease surveillance and monitoring systems for the diabetic community in the Caribbean since these tools may be used for better decision making. Future research could focus on mHealth tools in the surveillance of other non-communicable diseases (NCDs).*

Keywords: *Diabetes surveillance and monitoring, mHealth, translational research and development, computer-based health informatics, information systems, mobile app, type 2 diabetes, NCDs*

1. Introduction

Non-communicable diseases adversely affect many households in low-income countries, including the poor (Kankeu et al, 2013). Approximately 150,000 Jamaicans (8% of the population) suffer from diabetes (Wilks et al, 2008). Effective surveillance systems of non-communicable diseases may reduce the occurrence of chronic diseases (Alleyne, 2016). The probability of NCDs being prevented is increased by identifying major common risk factors and their prevention and control (Riley et al., 2016). THE LANCET NCD Action Group and the NCD Alliance propose five overarching priority actions for the response to the crisis including "monitoring and accountability" (Beaglehole et al, 2011). With the increased use of smart phones, there is an opportunity for patients living with diabetes to report and monitor health data – using mobile apps or interactive web sites – for increased accountability. Moreover, Chen et al (2016) indicate that most persons (77%) are willing to share their personal health data for research. Notably, in a recent systematic review on the economic evaluations of mHealth interventions, most studies (29 of 39) reported cost savings at base case (Iribarren et al, 2017). In contrast, another review reported that the evidence supporting the effectiveness of mHealth tools to better facilitate adherence to chronic disease management is mixed (Hamine et al, 2015). As such, there is an opportunity to assess the acceptance and utility of mHealth tools to address specific barriers to adherence of patients living with chronic diseases, such as type 2 diabetes.

Effective strategies used in the assessment of eHealth acceptance stem from theories related to technology acceptance and behaviour change (Duplaga, 2015). The most commonly used models for examining users' acceptance of mHealth products and services are Technology Acceptance Models (TAMs) and their extensions as well as the Unified Theory of Acceptance and Use of Technology (UTAUT) (Jeon & Park, 2015). Notably, the UTAUT model can explain as much as 70% of the variance in intention to use a technology (Venkatesh et al.,2003); the predictive strength of UTAUT was confirmed by a meta-analysis of 43 studies (Dwivedi et al., 2011). At least one theoretical technology acceptance model has been developed specifically for the health field, i.e. the Health Information Technology Acceptance Model (HITAM). The initial HITAM indicated that the model accounted for

83% of the variance in behavioural intention (Kim & Park, 2012); however, the second HITAM study showed a marked reduction in ability to predict behavioural intention by only 34.6% (Kim, 2014). Conceptually, UTAUT and HITAM are possibly the best constructs towards technology acceptance in the health context. As such, it may be suitable to extend constructs of UTAUT with elements of HITAM to determine behavioural intent to use MHealth in a healthcare context.

The study investigates the extent to which the diabetic community of Jamaica is willing to accept to use *MHealth (a mobile app for monitoring and surveillance of diabetes, MAMAS-Diabetes)* to report and analyze health data. (In this study, the diabetic community includes patients living with type 2 diabetes and health professionals.) Two research questions are addressed: (i) To what extent Jamaicans living with diabetes are willing to report their health data to the Ministry of Health and to Health Professionals? (ii) What are the factors influencing the acceptance of technology in using a mobile application for reporting health data for the purpose of disease surveillance in Jamaica?

2. Methods

Variables in the hypothetical model were derived from a combination of the most relevant variables used in the UTAUT and HITAM technology acceptance models. A questionnaire was created based on this hybrid theoretical model. One hundred surveys were issued to persons living with diabetes in Kingston, St. Andrew and St. Catherine, Jamaica; most of the questionnaires were issued at the Diabetes Association of Jamaica. This cross-sectional survey utilized convenience sampling.

Four (4) semi-structured interviews were conducted with health professionals to solicit their interest in the project and to provide feedback about the design a prototype mobile app. Some patients living with diabetes type 2 were asked to give feedback on the MHealth *MAMAS-Diabetes* prototype.

Table 1: Age Ranges of Participants in the Study

Age Group	*Number of participants*
18 – 39	16%
40 – 49	16%
50 – 59	27%
60 – 69	25%
70+	16%

Seventy-three percent (73%) of the participants were female. Educational levels varied; thirty-five (35%) of the participants had completed secondary education while twenty-seven (27%) had tertiary education. Most of the participants (68%) were over fifty years of age (see Table 1). Most of the participants had a mobile phone; sixty-five (65%) had a smart phone while 43% had a basic phone.

3. Results

All four (4) health professionals interviewed indicated that mHealth could be a useful tool. Physicians noted that some patients were already recording blood sugar levels and sending this data electronically to their doctor, e.g. email. However, an expected challenge would be in patient compliance. One suggestion is to give incentives to increase compliance, e.g. free blood sugar reading and free medication. Other suggestions for the prototype included providing exercise tips and adding A1C blood results in the patient reporting options.

Table 2: Willingness to report health data among diabetic patients

	Willingness to report to Ministry of Health	*Willingness to report to medical doctor*
Blood Sugar	90%	99%
Blood Pressure	90%	99%
Weight	87%	98%
Lifestyle behaviors	85%	95%
Waist Measurement	81%	93%
Geographic Location	72%	86%

Patients living with diabetes are more willing to report health data to their medical doctor than to the Ministry of Health (see Table 2). Significantly, the willingness to share health data is over eighty percent (80%) for relevant

health data; it is not surprising that there is a greater reluctance to share demographic data (i.e. geographic location) via a mobile device.

The most desired features of the mobile monitoring system include dietary or exercise suggestions (67%), medical care suggestions (65%), appointment scheduling/ reminders (60%) and visual displays of health (58%) [see Table 3]. It is surprising that that there is less interest in tailored education (45%) and tailored feedback (42%) than all of the other possible mHealth *MAMAS-Diabetes* features.

Table 3: Level of interest in mHealth features among diabetic patients

Feature of mobile monitoring system for diabetic patients	*Level of Interest*
Dietary or Exercise Suggestions	67%
Medical Care Suggestions	65%
Appointment Scheduling/ reminders	60%
Visual displays of health	58%
Tailored educational material	45%
Tailored feedback	42%

There was a high or moderate correlation between the willingness to report health data and several variables on the questionnaire (see Table 4). The factors influencing the acceptance of technology for reporting health data include performance expectancy (r = .928, p < .01), social influence (r = .804, p < .01), and health belief and concerns (r = .513, p < .01). Not surprisingly, patients living with diabetes are more likely to be willing to use mHealth *MAMAS-Diabetes* if they believe it will work (performance expectancy) and if other persons who are significant to this patient also exert influence to use a new system (social influence). Effort expectancy was *not* linked to the willing to report health data in the sample of patients living with diabetes. In contrast, health beliefs and concerns may have some association with behavioural intention to use mHealth *MAMAS-Diabetes.*

Table 4: Correlation of constructs with willingness to report health data among diabetic patients

	Pearson Correlation	*Sig. 2 (2-tailed)*
Performance Expectancy	.928**	.000
Social Influence	.804**	.000
Effort Expectancy	-.028	.779
Health Belief and Concerns	.513**	.000

Since the investigators used convenience sampling, the correlations noted above are computed without compliance with all of the underlying assumptions of rigorous statistical methods. As such, the results should be used with caution (since a non-probability sampling method was utilized).

4. Conclusion

There is a strong level of interest in a mHealth Disease Surveillance and Monitoring system among patients and health professionals. The majority of adult Jamaicans living with diabetes are willing to share health data with the Ministry of Health and their health professionals. The factors influencing the acceptance of technology for reporting health data include performance expectancy, social influence, and health belief and concerns.

Based on the evidence in the study, policy makers should consider the implementation of computer-based disease surveillance and monitoring systems for diabetes in Jamaica. Based on the data, it may be best to start with monitoring before surveillance as part of the strategy towards successful adoption. Since performance expectancy and social influence may be associated with the willingness to use MHealth apps in the diabetic community, it is especially important that attention is paid to these concepts during a pilot project. Future research should focus on understanding which steps could be taken to overcome barriers to the adoption of mHealth tools in diabetes surveillance and monitoring; it is likely that the influence of health professionals and family members may be key to success of mHealth *MAMAS-Diabetes.*

Acknowledgements:

Research work was conducted by students Ryan Panton, Dwayne Walters, Kyle-Anthony Smith, Weaveney Jones, Ashani Martin, Damion Anglin and Maurice Swaby.

References:

Alleyne, G. (2016), "Economic dimensions of non-communicable diseases in Latin America and the Caribbean: Policy agenda considerations", *Economic Dimensions of Non-communicable Diseases in Latin America and the Caribbean*, pp.143.

Beaglehole, R., Bonita, R., Horton, R., Adams, C., Alleyne, G., Asaria, P., and Cecchini, M. (2011), "Priority actions for the non-communicable disease crisis", *The Lancet*, Vol.377, No.9775, pp.1438-1447.

Chen, J., Bauman, A., and Allman-Farinelli, M. (2016), "A study to determine the most popular lifestyle smartphone applications and willingness of the public to share their personal data for health research", *Telemedicine and e-Health*, Vol.*22*, No.8, pp.655-665.

Duplaga, M. (2015). "A cross-sectional study assessing determinants of the attitude to the introduction of eHealth services among patients suffering from chronic conditions", *BMC Medical Informatics and Decision Making*, Vol.15, No.1. Available from https://doi.org/10.1186/s12911-015-0157-3

Dwivedi, Y.K., Rana, N.P., Chen, H., and Williams, M.D. (2011), "A Meta-analysis of the unified theory of acceptance and use of technology (UTAUT)", In: Nüttgens, M., Gadatsch, A., Kautz, K., Schirmer, I. and Blinn, N. (Eds.), *Governance and Sustainability in Information Systems. Managing the Transfer and Diffusion of IT* (pp. 155–170). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-24148-2_10

Hamine, S., Gerth-Guyette, E., Faulx, D., Green, B. B., and Ginsburg, A.S. (2015), "Impact of mHealth chronic disease management on treatment adherence and patient outcomes: A systematic review", *Journal of Medical Internet Research*, Vol.17, No.2

Iribarren, S. J., Cato, K., Falzon, L., and Stone, P. W. (2017), "What is the economic evidence for mHealth? A systematic review of economic evaluations of mHealth solutions", *PloS one*, Vol.12, No.2, e0170581.

Jeon, E., and Park, H.-A. (2015), "Factors affecting acceptance of Smartphone application for management of obesity", *Healthcare Informatics Research*, Vol.21, No.2, pp.74. https://doi.org/10.4258/hir.2015.21.2.74

Kankeu, H. T., Saksena, P., Xu, K., and Evans, D. B. (2013), "The financial burden from non-communicable diseases in low-and middle-income countries: A literature review", *Health Research Policy and Systems*, Vol.11, No.1, pp.31.

Kim, J. (2014), "A qualitative analysis of user experiences with a self-tracker for activity, sleep, and diet", *Interactive Journal of Medical Research*, Vol.3, No.1. Available from https://doi.org/10.2196/ijmr.2878

Kim, J., and Park, H.-A. (2012), "Development of a health information technology acceptance model using consumers' health behaviour intention", *Journal of Medical Internet Research*, Vol.14, No.5, e133. https://doi.org/10.2196/jmir.2143

Riley, L., Guthold, R., Cowan, M., Savin, S., Bhatti, L., Armstrong, T., and Bonita, R. (2016), "The World Health Organization STEPwise approach to non-communicable disease risk-factor surveillance: Methods, challenges, and opportunities", *American Journal of Public Health*, Vol.106, No.1, pp.74–78. Available from http://doi.org/10.2105/AJPH.2015.302962

Venkatesh, V., Morris, M.G., Davis, G. B., and Davis, F.D. (2003), "User acceptance of information technology: Toward a unified view", *MIS Quarterly*, pp.425-478.

Wilks, R., Younger, N., Tulloch-Reid, M., McFarlane, S., and Francis, D. (2008). *Jamaica Health and Lifestyle Survey 2007-8*. Tropical Medicine Research Institute, University of the West Indies, Mona, Jamaica

Author's Biographical Notes:

Susan A. Muir *is Lecturer in the School of Computing and Information Technology, UTech Jamaica, has research interests in translational health and sports informatics, research ethics and computer-based behaviour change interventions. Her studies have included a Master of Science in Computer-based Management Information Systems, a Master in Public Health, and a graduate diploma in Research Ethics. She is the Western Regional representative for the Bioethics Society of the Caribbean, member of the Jamaica Computer Society, member of Women Media Watch Jamaica, health coach, motivational speaker, and founder of the "AweMaze Fitness Transformation Support" Facebook group.*

■

The Impact of Fitspiration (via Social Networking Sites and Mobile Applications) on the Physical Activity Levels and Body Image of Female University Students

Susan A. Muir

Faculty of Engineering and Computing, University of Technology, Jamaica, West Indies; Email: smuir@utech.edu.jm;

Abstract: *There is evidence that women are physically inactive (compared to their male counterparts) and that social networking sites (SNS) are popular among young women. Fitspiration (or fitspo) can be described as any media that intends to motivate someone to exercise or to be healthy; it is prevalent on SNS. Research indicates that the use of fitspiration is linked to negative body image and mental disorders among women. To date, there is paucity of research on fitspiration in developing countries. The aim of this study was to investigate the impact of fitspiration on the physical activity levels (PAL) and body image among female university students in urban Jamaica. This project also explored the prevalence of the use of fitspiration, as well as the perception of fitspiration on SNS and mobile apps. This research had three (3) phases: Phase 1 – focus groups of urban Jamaican female university students about fitspo, Phase 2 – an experimental study (that begun with over 100 participants) with two arms: an experimental group (exposure to an Instagram page with fitspo) and a control group, and Phase 3: interviews about interest in fitspiration mobile apps. Most female Jamaican university students (63% of the sample) heavily utilise SNS and have a fairly positive perception of fitspiration; yet these students view relatively little fitspiration content regularly (unlike their counterparts in some developed countries). Based on interviews and focus groups, most female Jamaican university students are interested in using a fispiration mobile app and/or viewing 'fitspo' on SNS. The qualitative results indicate that there are distinct preferences of students for particular body types portrayed in fitspiration (images and videos). Over one-quarter of the female students compared their bodies to those that they saw on SNS, while only a few (7%) reported a poor body image. This exploratory study indicates that viewing fitspiration may have little impact on physical activity level or fitness motivation in a short intervention (i.e. one week). This type of research could be replicated among students for a longer period and targeted at persons with health challenges such as diabetes or obesity. The implications of the study may be beneficial to health promotion specialists, mobile app developers, fitness businesses and public health organisations.*

Keywords: *Computer-based Health Informatics, Social Networking Sites (SNS), Mobile Application, Physical Activity Level (PAL), Body Image, Fitspiration, Female Youth, Instagram, translational research*

1. Introduction

Many Jamaican women (43%) are classified as being inactive (Wilks et al, 2008). Social media use is particularly popular among young women (Kimbrough et el., 2013). The frequent usage of several social networking sites (SNS) with fitspiration, has contributed to females manifesting habits to achieve fitness goals (Jong & Drummond, 2016). Fitspiration can be described as any media that intends to motivate someone to exercise or to be healthy. Fitspiration is a popular trend on SNS, especially on Instagram; the culture is mostly dominated by women who have received millions of followers and a substantial amount of fame from such accounts (Bohjalian, 2017). The nature of fitspiration content is primarily exercise (74%) and food and dieting (20%) (Carotte et al, 2017).

The majority of fitspiration content motivates individuals towards fitness because of the following outcome expectancies: improved physical appearance (attractiveness), accomplished self-worth and happiness, and improved health for mind and body (Simpson and Mazzeo, 2017). Research indicates that fitspiration is linked to negative body image among women (Fardouly & Vartanian, 2016). When exposed to athletic ideals or images, females are more likely to engage in gym related physical activity, internalize the images, and carry out guilt-fueled compulsive exercise and eating habits (Boepple and Thompson, 2016). Surprisingly, there is paucity of research on the impact of fitspiration on physical activity levels (or fitness). Moreover, most fitspiration research is conducted in developed countries.

This study investigates the impact of fitspiration on Jamaican female university students. The study explores three (3) research questions: (i) How frequent do Jamaican female university students view "fitspiration" on social media? (ii) What is the perception of Jamaican female university students towards "fitspiration"? (iii) What is the impact of "fitspiration" on fitness level of Jamaican female university students?

2. Methods

This multiple methods research has three (3) phases: Phase 1: Focus groups of urban Jamaican female university students, Phase 2: Experimental study, and Phase 3: Interviews about fitspiration artefacts (mobile app and social media). The female population of UTech Jamaica includes over seven thousand students. The qualitative data consists of thirty (30) participants in Phase 1 and thirty-eight (38) female students who were interviewed briefly in Phase 3. The quantitative data included one hundred and two participants (102 pre-test online questionnaires and 22 post-test questionnaires). The majority of the students (89 of 102) participants in the pre-test questionnaire were between ages eighteen to twenty-four (18 – 24).

Each participant in Phase 2 was asked to complete two questionnaires (pre-test and post-test) that included the IPAQ (International Physical Activity Questionnaire). This short form has moderate validity (Silsbury, Goldsmith, & Rushton, 2015). The participants who completed the experiment were exposed to either a "Fitspiration" Instagram page (experimental group) or to a "Good Mood" Instagram page (control group). [The group that was asked by email to utilize the mobile app did not install the application, as planned.] Due to attribution, only forty (40) participants were a part of the experiment. Moreover only twenty-two (22) participants completed the post questionnaire. Seventeen (17) of these data points were able to be utilized in the results and data analysis of the prospective study.

3. Results

Many female Jamaican university students indicated a high level of interest in fitspiration in the focus group, although the majority (29 of 30 in the focus group) had never heard of the term "fitspo" or "fitspiration". Moreover, the initial online survey indicated that only a minority (13 of 102) posted fitspiration on social media. For example, these results are in *stark contrast* to the findings of another study where more than 50% of the participants in that study would normally take exercise related "selfies" and regularly post about their fitness and health practices on social media (Vaterlaus et al 2015). Notably, there is evidence in this survey that there is a low level of fitness among Jamaican female university students; moreover, most female Jamaican university students (63%) heavily utilized social media. In particular, 41 of 102 indicated that they used it more than four hours daily (> 4 hrs) while 23 of 102 indicated that they used it between four to six hours daily (4 – 6 hrs). The most popular social media accounts among these students are *WhatsApp* (40 of 102), *Instagram* (33 of 102), and *Facebook* (19 of 102).

The survey also indicated that over 30% of the female students never followed fitspiration. Only 32% of the participants had decided to follow fitness-related content *regularly* on SNS: 4% reported that following fitspiration regularly, 28% followed fitspiration "sometimes" and 38% had followed fispiration at least once (see Figure 1).

The survey indicated that about 1/3 of the female university students in the study compared themselves with other bodies on social networking sites (see Figure 2). Notably, many students believed that fispiration did *not* have an impact on their individual body image; however, 19% of respondents agreed that felt badly after viewing fitspiration (see Figure 3). On a similar note, most of female university students in the focus group sessions agreed that is acceptable to maintain fitness solely for appearance reasons. One participant stated, "*When you look good, you feel good"*.

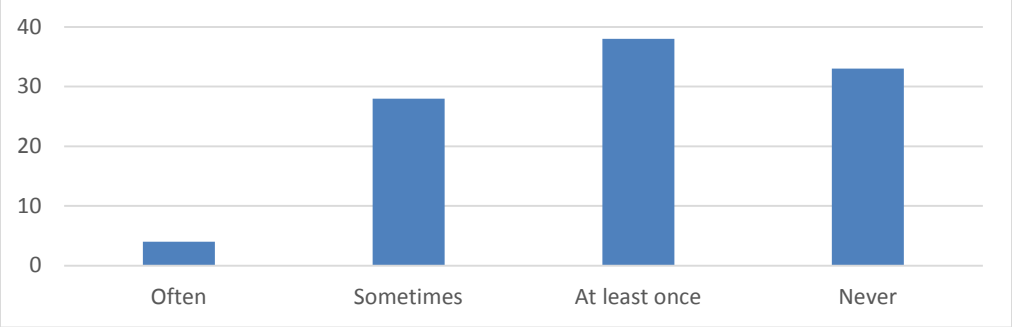


Figure 1: Self-reported Frequency of following fitness related content on SNS

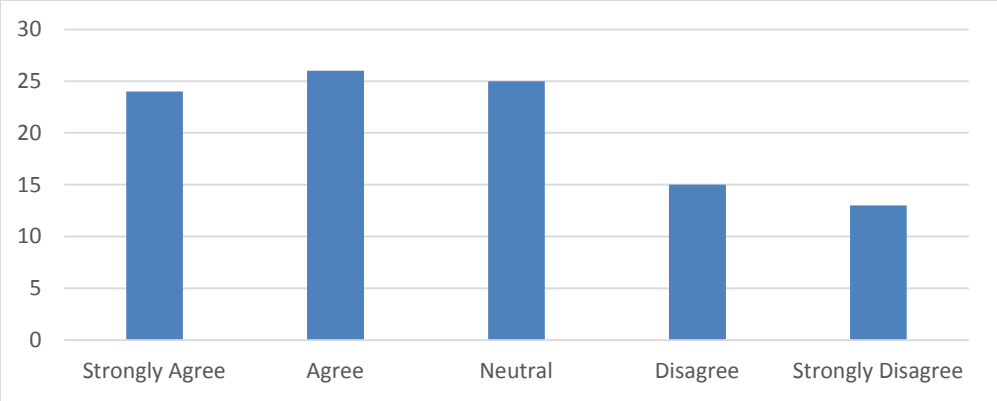


Figure 2: Comparison of physical body of student to other body images on SNS

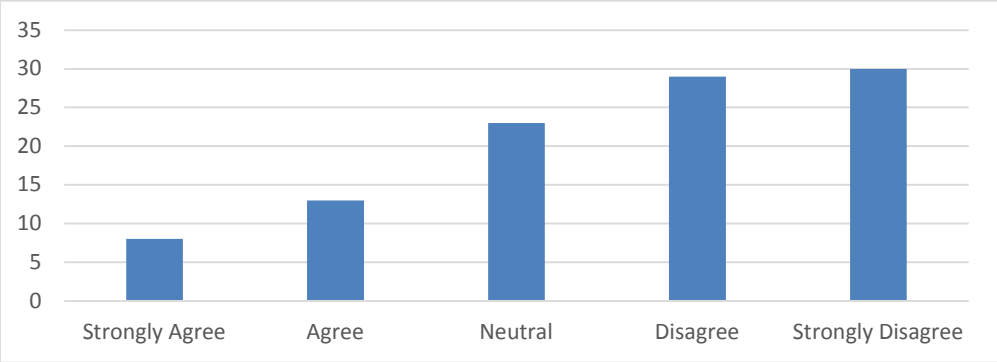


Figure 3: Negative Body Image after viewing fitness related content on SNS

Due to attrition, only seventeen (17) participants were involved in the Instagram prospective study. This prospective study was designed as an experiment; to mitigate confounding, the research team stratified the forty (40) subjects at entry according to their physical activity levels (*using the International Physical Activity Questionnaire MET levels)* so that each arm in the experiment had similar levels of physical activity. Moreover, since subjects did not respond to the follow-up email, the research team manually added each participant with an Instagram account to follow a randomly selected Instagram page (since the participants had already consented to participate earlier in the semester). All of the participants completed the short form of the IPAQ (International Physical Activity Questionnaire). Within the small sample that completed the post-test, there was a noticeable difference between the vigorous physical activity levels among the two arms of the experiment.

It is notable that vigorous exercise increased among two of the nine persons exposed to the "Good Mood" Instagram posts while no participant exposed to the "Fitspiration" Instagram posts increased their level of vigorous physical activity (see Table 1). However, this difference is *not* statistically significant. Moreover, there was also no difference in the intention to become involved in fitness activities after the one-week intervention. Surprisingly, there is a *possibility* that positive mood may improve vigorous physical activity levels among some female university students; however, there is no confidence in these results given the small sample size.

As noted earlier, the research participants who are asked to download the mobile app did not comply; as such, the research team devised Phase 3, in which thirty eight (38) female university students were interviewed to see the level of interest in the fispiration mobile app and the Instagram fitspiration. Notably, many of these students expressed perceived value in the mobile app because of the ease of use and the ability to download videos on the phone for future use (when *WiFi* Internet service was not available).

Table 1: Vigorous physical activity for Instagram "Fitspiration" versus "Good Mood" arms

IPAQ Vigorous Activity			
Instagram "Fitspiration" Participants			
	Before	After	Difference
Participant 1	60	0	-60
Participant 2	0	0	0
Participant 3	0	0	0
Participant 4	60	0	-60
Participant 5	480	150	-330
Participant 6	5	2	-3
Participant 7	90	0	-90
Participant 8	20	6	-14
Average of "Fitspiration" arm	89.38	19.75	-69.63
Instagram "Good Mood" Participants			
	Before	After	Difference
Participant 9	0	0	0
Participant 10	60	0	-60
Participant 11	60	0	-60
Participant 12	450	0	-450
Participant 13	360	945	585
Participant 14	240	960	720
Participant 15	5	2	-3
Participant 16	10	0	-10
Participant 17	60	60	0
Average of "Good Mood" arm	138.33	218.56	80.22

4. Limitations

There were a number of logistic challenges in this research project, e.g. the intervention was conducted for only seven (7) days; the experiment with a mobile app was not conducted, as initially planned. Moreover, in retrospect the investigators could have performed additional qualitative data collection (e.g. additional focus groups with the mobile app) to facilitate the experiment. Given the methodological limitations, we are unable to generalize about the impact of fitspiration on the population of female university in this setting (a local Jamaican university), given the small sample size of the prospective study.

5. Conclusion

Jamaican female university students view relatively little fitspiration content, even though the frequency of their use of social media is relatively high. These students have a fairly positive perception of fitspiration. Based on interviews and focus groups, many female university students are interested in using a fispiration mobile app and/or viewing 'fitspo' social media. Based on the empirical data, fispiration may have a negative impact on body image of some female Jamaican university students. This exploratory study indicates that fitspiration may have little impact on the fitness levels or the fitness motivation in a short-lived intervention (i.e. one week).

The research could be replicated for university students for a longer period, for women over thirty, and/or for persons with health challenges. Incentives (e.g. raffle prizes) may reduce the attrition in future experimental studies. The results may be beneficial to health promotion specialists, fitness businesses and public health organizations.

Acknowledgements:

Research work was conducted by students Camille Simmonds, Jessica Mendez, Suwayne Morrison, Romario Richards, and Shante Watson.

References:

Boepple, L., and Thompson, J. K. (2016), "A content analytic comparison of fitspiration and thinspiration websites", *International Journal of Eating Disorders*, Vol.49, No.1, pp.98-101.

Bohjalian, E. (2017), "The self-presentation of popular fitspiration experts on Instagram", *Elon Journal of Undergraduate Research in Communications*, Vol. 8, No. 1, Spring,

Carrotte. E.R., Vella. A.M., and Lim, M.S. (2015), "Predictors of "liking" three types of health and fitness-related content on social media: A cross-sectional study", *Journal of Medical Internet Research*, Vol.17, No.8: e205. doi: 10.2196/jmir.4803. Available from http://www.jmir.org/2015/8/e205/

Fardouly, J., and Vartanian, L. R. (2016), "Social media and body image concerns: Current research and future directions", *Current Opinion in Psychology*, Vol.9, pp.1-5.

Jong, S. T., and Drummond, M. J. (2016), "Exploring online fitness culture and young females", *Leisure Studies*, Vol.35, No.6, pp.758-770.

Kimbrough, A.M., Guadagno, R.E., Muscanell, N.L., and Dill, J. (2013), "Gender differences in mediated communication: Women connect more than do men", *Computers in Human Behaviour*, Vol.29, pp.896-900. Retrieved from: http://dx.doi.org/10.1016/j.chb.2012.12.00

Silsbury, Z., Goldsmith, R., and Rushton, A. (2015), "Systematic review of the measurement properties of self-report physical activity questionnaires in healthy adult populations", *BMJ Open*, Vol.5, No.9, e008430.

Simpson, C. C., & Mazzeo, S. E. (2017). Skinny is not enough: A content analysis of fitspiration on Pinterest. *Health communication*, *32*(5), 560-567.

Vaterlaus, J. M., Patten, E. V., Roche, C., and Young, J. A. (2015). "Gettinghealthy: The perceived influence of social media on young adult health behaviours", *Computers in Human Behaviour*, Vol.45, pp.151-157.

Wilks, R., Younger, N., Tulloch-Reid, M., McFarlane, S., and Francis, D. (2008). *Jamaica Health and Lifestyle Survey 2007-8*. Tropical Medicine Research Institute, University of the West Indies, Mona, Jamaica

Author's Biographical Notes:

Susan A. Muir *is Lecturer in the School of Computing and Information Technology, UTech Jamaica, has research interests in translational health and sports informatics, research ethics and computer-based behaviour change interventions. Her studies have included a Master of Science in Computer-based Management Information Systems, a Master in Public Health, and a graduate diploma in Research Ethics. She is the Western Regional representative for the Bioethics Society of the Caribbean, member of the Jamaica Computer Society, member of Women Media Watch Jamaica, health coach, motivational speaker, and founder of the "AweMaze Fitness Transformation Support" Facebook group.*

■

The Fermentation of the Pulp of Watermelon (*Citullus lanatus*) in the Absence and Presence of Metal Additives with a View to Obtain Ethanol for Commercial Use

Raymond C. Jagessar[1], and Jamacey Lynch[2]

[1]Department of Chemistry, University of Guyana, South America; E-mail: raymondjagessar@yahoo.com
[2] Department of Biology, University of Guyana, South America; E-mail: Jamaceydionnelynch@hotmail.com

Abstract: *There has been increased interest in the use of renewable energy such as Bio-ethanol, with a view to decrease dependence on fossil fuel and curb global warming. Bio-ethanol can be used for a variety of purposes, of which blending with gasoline to produce gas alcohol to power automobiles is on the increase. Ethanol can be obtained via the fermentation of glucose or sucrose under the influence of Saccharomyces cervisae at room temperature or acid hydrolysis of lignocellulose material followed by subsequent fermentation. In this research, the sugar rich pulp of watermelon mash was fermented in the absence and presence of additives such as $ZnSO_4$, Promalt, Potassium Phosphate, Yeastex. Fermentation was conducted at a pH of 4.5 at room temperature for 72 hours. In the absence of additives, an average alcoholic strength of 4.23 v/v was obtained. In the presence of additives, $ZnSO_4$, Promalt, Potassium phosphate, Yeastex, an alcoholic strength of 5.10 v/v, 3.37 v/v, 4.09 v/v, 4.19v/v was obtained respectively. For the Reference molecule, glucose without additives, an average alcoholic strength of 6.14 (v/v) ethanol was obtained. For glucose molecule with potassium phosphate, promalt, $ZnSO_4$ and Yeastex, an average alcoholic strength of 7.52, 4.19, 7.11 and 5.53, v/v was obtained respectively. The additives did had an effect on the alcoholic strength. $ZnSO_4$ increased the alcoholic strength for the fermented watermelon matrix, whereas for the reference molecule glucose, potassium phosphate and Yeastex did increase the alcoholic strength. It is anticipated that future fermentation research on the above should continue with a view to increase the ethanolic content beyond 15%, the maximum recorded in the literature. From thereon, the ethanol can be commercialised of which, one useful application is the blending with gasoline to produce gas-alcohol.*

Keywords*: Bio-ethanol, Saccharomyces cervisae, additives, ethanolic strength, potassium phosphate, Yeastex*

Authors' Biographical Notes:

Raymond C. Jagessar *obtained his BSc (Distinction) in Chemistry/Biology from the University of Guyana (1992) and his PhD from the UK (1995). He is currently Professor in Chemistry at the University of Guyana (South America). He held three Post Doctoral Research Fellowships (PDF) at the University of South Carolina (USA), Wichita State University (USA) and the University of the West Indies during the period, 1996-1999. Professor Jagessar has won several international awards, amongst them, Chartered Chemist, CChem and Fellow of the Royal Society of Chemistry, FRSC, UK, and Research Grants etc. His research interests are broad, covering the spectrum of Pure and Applied Chemistry, Chemical Biology and Pharmaceutical Chemistry. He has published over seventy (75) research articles, five book chapters and presented at several international conferences, locally and internationally.*

Jamacey Lynch *was a final year Biology major student (2016-2017) at the University of Guyana. Her final year project, entitled, "The fermentation of the pulp of watermelon (citullus lanatus) in the absence and presence of metal additives with a view to obtain ethanol for commercial use" was supervised by Professor R.C. Jagessar. She is currently employed at an Organisation in Guyana. She graduated from the University of Guyana,*

■

The Status of Surface Water in Linden and Coastal Guyana

Raymond C. Jagessar[1], and Reshmee Lakhan [2]

[1]Department of Chemistry, University of Guyana, South America; E-mail: raymondjagessar@yahoo.com
[2] Department of Biology, University of Guyana, South America; E-mail: reshmee.lakhram@yahoo.com

Abstract: *There is an urgent need to assess the status of surface water, so as to safeguard against chemical and biological pollutants, so as to aid in its further purification when necessary. The status of surface water was determined for several selected areas of coastal Guyana. These were Linden, Cane Grove, Botanical Gardens, Non-Pariel, Utvlugt, Turkeyen and N0. 62 village. Both physio-chemical properties and the concentration of cation and anion in mg/L were determined. The cation and anion concentration was determined via pre-treatment of the sample (digestion), followed by making up of the requisite solution at a specified concentration in volumetric flasks and the analyses of a known volume of the solution (analyte) via Flame Atomic Spectroscopy. The physical properties determined were temperature, pH, Turbidity, EC, Total dissolved solids, TDS. These were all determined using standard experimental reviewed protocols. Bacterial analyses were conducted via the Membrane Filtration Method. Total Coliform was also determined. The pH range from 5.01 ± 0.01 to 6.17 ± 0.02, whereas EC (us) and TDS (mg/L) was found to range from (26.7 ± 0.26 μs to 484 ± 1.15 μs) and (18.7 ± 0.15 mg/L to 343 ± 4.36 mg/L). Dissolved oxygen content (DO) range from (1.0 ± 0.0 mg/L to 5.0 ± 0.0 mg/L), whereas salinity varied from 12.5 ± 0.05 ppm to 233.0 ± 0.1 ppm. All these physical factors with the exeception of Turbidity and EC at No. 62 village, were below WHO standards. With respect to the cations, there was no detection for cadmium in any of the surface water, with the exception of Cane Grove Surface water, which registered a value of 0.47 ± 0.03 mg/L. There was no detection for Pb, in any of the surface water. Aluminum detection range from (0.2 ± 0.03 mg/L to 0.43 ± 0.03 mg/L). Fe detection range from 0.01 ± 0.002 mg/L to 0.07 ± 0.03 mg/L. Cu detection was found to be constant at 0.01 ± 0.02 mg/L for all Surface water, whereas Zn showed detection in the range (0.04 ± 0.03 mg/L to 0.17 ± 0.03 mg/L). With respect to anions, there was no detection for nitrate, whereas SO_4^{3-} and PO_4^{3-} detection was found in the range (2.93 ± 0.02 mg/L to 20 ± 1.53 mg/L) and (0.06 ± 0.011 mg/L) to 1.10 ± 0.01 mg/L) respectively. All cations concentration, were below WHO standards. For the anions, only chloride at No. 62 village surface water was above WHO standards.*

Keywords*: Surface water, anions, cations, detection, permissible range*

Authors' Biographical Notes:

Raymond C. Jagessar *obtained his BSc (Distinction) in Chemistry/Biology from the University of Guyana (1992) and his PhD from the UK (1995). He is currently Professor in Chemistry at the University of Guyana (South America). He held three Post Doctoral Research Fellowships (PDF) at the University of South Carolina (USA), Wichita State University (USA) and the University of the West Indies during the period, 1996-1999. Professor Jagessar has won several international awards, amongst them, Chartered Chemist, CChem and Fellow of the Royal Society of Chemistry, FRSC, UK, and Research Grants etc. His research interests are broad, covering the spectrum of Pure and Applied Chemistry, Chemical Biology and Pharmaceutical Chemistry. He has published over seventy (75) research articles, five book chapters and presented at several international conferences, locally and internationally.*

Reshmee Lakhan *was a final year Biology major student (2015-2016) at the University of Guyana. Her research project, "The status of surface water in Linden and coastal Guyana", was supervised by Professor R.C. Jagessar. She is currently employed at an organisation in Guyana.*

■

Synthesis of Nanoparticle of Carbon

Thierry Cesaire[1], Gabriel Carbonnel[2], Yves Bercion[3], Audrey Molza[4], and Philippe Thomas[5]

[1,2,5] Laboratoire GTSI , EA2432 Université des Antilles et de la Guyane, BP 250, 97157 Pointe à Pitre Cedex, Guadeloupe.
[1]E-mail: thierry.cesaire@univ-ag.fr;
[2]Email: carbonnelg10@gmail.com;
[5]Email: philippe.thomas@univ-ag.fr;

[3,4] C3MAG, Université des Antilles et de la Guyane, BP 250, 97157 Pointe à Pitre Cedex, Guadeloupe.
[3]E-mail: yves.bercion@univ-ag.fr;
[4]E-mail: audrey.molza@univ-ag.fr;

Abstract: *Friction and wear are the first causes of the decrease of the performances and the durability of mechanical systems. The role of lubrication is to minimise friction between the sliding surfaces and to protect them from wear. Conventional liquid lubricants are constituted of base oil and additives presenting specific properties, such as friction reduction, anti-wear or anti-oxidising action. Commercial lubricants generally use graphite and petroleum-based oils because of their recognised lubricating properties, their stability and low cost. However, such lubricants induce health and environmental hazards due to their life cycle. The aim of this work is to investigate the possibility to use local biomass in order to produce environmentally-friendly lubricants. Local vegetable oils are interesting candidates because of their inherent qualities like renewability, bio-degradability, non-toxicity. So, the first objective consists in finding an optimal mixture of mineral oil and vegetable oil validated by a compromise between environmental impact and cost of the lubricant. Our study mainly concerns the synthesis of new friction reducer additives. New carbon phases are obtained from glycolic solutions, stemming from by-products of our agriculture, using the spray-pyrolysis technique. This technique consists in nebulising in the form of micro-droplets a solution of saccharose, transported via a carrier neutral gas in a tubular oven heated at temperature ranging from 600°C to 1,000°C. Carbon nanoparticles are then obtained. Here are described the promising first results related to the determination of the optimal synthesis conditions, i.e. the catalyst concentration, the carrier gas pressure and the temperature of the tubular oven. Scanning electron microscopy and Raman spectrometry analyses are carried out, allowing us to observe the spherical shape and the porosity of the particles and to determine the graphitisation degree of the carbon phases.*

Keywords: *Spray pyrolysis, Tribology, Lubrication*

References:

Fortunato, M.E., Massoud Rost-Abadi, M., and Suslick, K.S. (2010), "Nanostructured carbons prepared by ultrasonic spray pyrolysis**",** *Chemistry of Materials*, Vol.22, pp.1610-1612 DOI:10.1021/cm100075j

Hu, C., and Sedghi, S. (2015), "Raman spectroscopy study of the transformation of the carbonaceous skeleton of a polymer-based nanoporous carbon along the thermal annealing pathway**",** *Elsevier Carbon*, Vol 85, pp.147-158

Thomas, P.B, Molza, A., Legras, L., Mansot, J.L., Guérin, K., and Dubois, M. (2016), "Fluorinated Nanocarbons for Lubrication", In: Olga Boltalina, Tsuyoshi Nakajima and Alain Tressaud, (ed.), *New Fluorinated Carbons: Fundamentals and Applications*, Elsevier Inc., Chapter 14, pp.325-360.

Authors' Biographical Notes:

Thierry Cesaire *is responsible of the development of a new synthesis technique of nanoparticles, by spray-pyrolysis of sugar cane. His work focuses on the structural and electronic characteristics of materials studied in Tribology. Especially the correlation between electronic and molecular structure and tribological properties is highlighted by the use of the electronic energy loss spectroscopy and Raman spectroscopy*.

Gabriel Carbonnel *is a chemistry student of the Institute academic and technological of Toulouse, under the direction of Dr. Thierry Cesaire, he set up the manufacturing of nanoparticles under flow of argon, and achieved satisfactory results. This student was valedictorian.*

Yves Bercion *is an engineer at C3MAG, and is in charge of all the laboratory equipment. It is particularly concerned with electronic and optical microscopes. He also manufactured all GTSI' tribometers and the associated acquisition.*

Audrey Molza *is an engineer at C3MAG and is particularly in charge of the RAMAN microscope and other microscopes. She completed her doctoral thesis on 'Colloidal Particle Lubrication': colloidal additive mechanisms' approach by in situ analyses in dynamic contact*

Philippe Thomas *is specialised in carbon materials, and is involved in new lubrication strategies studies. Recent works have shown that carbon nanoparticles are interesting candidates that can be used as friction reducers in liquid lubricants. Special attention is paid to the correlation between the friction properties and structural characteristics of the materials, such as morphology, graphitisation degree and surface properties.*

■

Tribological Properties of Vegetable Oils Added with Graphite Particles in Dodecane

Nadiege Nomede-Martyr[1], Jacques-Louis Ricard[2], Rachel Rossi[3], Philippe Bilas[4], Thierry Cesaire[5], and Philippe Thomas[6]

Groupe de Technologie des Surfaces et Interfaces (GTSI), EA 2432, University of French West Indies, 97159 Pointe a Pitre, Cedex France.

[1]E-mail: Nadiege.Nomede-Martyr@univ-antilles.fr;
[2]Email: jacques-louis.ricard@etu.iut-tlse3.fr;
[3]E-mail: rachel.rossi@etu.iut-tlse3.fr;
[5]E-mail: thierry.cesaire@univ-antilles.fr;
[6]Email: philippe.thomas@univ-antilles.fr;

Abstract: *Conventional liquid lubricants are constituted of a base oil and solid (nano)additives particles presenting specific properties, such as friction reduction and antiwear performances. Commercial lubricants generally use mineral base oils due to their recognised lubricating properties, their stability and especially competitive prices. However, vegetable oils present significant environmental benefits because of their inherent qualities like renewability, bio-degradability, and non-toxicity. Moreover, the friction coefficients obtained with vegetable oils ($\mu \approx 0.07$) are lower than the ones observed in the case of mineral oils (dodecane $\mu \approx 0.4$). In boundary lubrication, the thickness of the lubricant film is very weak and the lubricating performances are associated to the friction properties of (nano)additives. Graphite is usually used for lubrication because its lamellar structure induces good friction performances. In this study, the influence on the lubricating performances of vegetable oil addition in commercial mineral oil (dodecane) is evaluated. The influence of addition of exfoliated graphite is also investigated. The tribological tests are carried out using an alternative ball and plane tribometer at ambient temperature. The tribofilms obtained for the dodecane, vegetable oil and graphite blends are investigated by Raman spectroscopy and Scanning electron microscopy (SEM) analyses. These studies do not show degradation of the metallic surface during the sliding process.*

Keywords*: tribology, vegetable oil, graphite, lubricant*

Acknowledgements: *Thanks to region Guadeloupe, Synergile*

Authors' Biographical Notes:

Nadiege Nomede-Martyr *is Associate Professor since 2014 at the University of French West Indies in Guadeloupe. His expertise is in the field of tribology mainly macroscopic scale and fretting. She works with different shape of nano-particules ; graphite, fluorinated nanofibres, boron nitride… For BioTrib projet, she responsible of vegetable oil part.*

Jacques-Louis Ricard *is the first three-month internship student who worked on the subjet. «Study of tribological properties of vegetable oils » ; april to june 2017. He was in 2nd year of DUT Physical Measurement at IUT of University Toulouse III.*

Rachel Rossi *is the second three-months internship student who worked on the subjet. «Study of tribological properties of vegetable oils and mixtures friction reducer in temperature » ; april to june 2018. She was in 2nd year of DUT Chemical Engineering- Process Engineering at IUT of University Toulouse III.*

Philippe Bilas *is Associate Professor since 2009 at the University of French West Indies in Guadeloupe. His expertise is in the field of nanotribology mainly atomic force microscopy speciality. He works with different shape of nanocarbons particules ; graphite, fluorinated nanocarbons until to actived carbon.*

Thierry Cesaire *is responsible under the direction of Philippe Thomas as part of the project 'BioTrib' of the synthesis of nanoparticles by spray-pyrolysis of sugar cane. His work focuses on the characteristics of structural and electronic materials studied in Tribology. Especially the correlation between electronic and molecular structure*

and tribological properties is highlighted by the use of the electronic energy loss spectroscopy and Raman spectroscopy.

Philippe Thomas *is Professor at the University of French West Indies since 2014. His expertise is in the field of tribology at macroscopic scale. He have chemical skills and specialist of carbon particles. He is the project director of study of tribological evaluation of local biomass « BioTrib » (2017 to 2019).*

■

Integrated Health Information Systems for Diabetics in Guyana

Alicia Layne[1], Malcolm Williams[2], and Roland Daynauth[3]

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
[1]Email: alicia.layne@uog.edu.gy
[2]Email: malcolm.williams@uog.edu.gy
[3]Email: roland.daynauth@uog.edu.gy

Abstract: *Diabetes Self-Management Education (DSME) improves diabetic outcomes and reduces long term health complications in diabetics. Anecdotal evidence suggests that an Electronic Medical Record (EMR) integrated with a Personal Health Record (PHR) can assist the self-management education process as a comprehensive electronic condition control system. While this technology is theoretically valid, there is insufficient empirical data to support its widespread use (Grant et al., 2013). To address this, the technology should be applied to target populations for testing and refinement (Detmer et al., 2008). In response, the researchers conducted a design science research study to create a testing prototype that would generate needed empirical data and ultimately ascertain the usefulness of the integrated Electronic Medical Record-Personal Health Record technology in Guyana's context. A country-specific framework was derived from the International Organisation for Standards (ISO)/Health Level 7 (HL7) Personal Health Record System Functional Model (PHR-S FM).*

The standardised functions outlined in the model were assessed for potential implementation in the prototype based on the availability of requisite architectural support and data in Guyana's ICT space. The framework was then refined to be diabetes-specific through primary research conducted in the diabetic healthcare sector. Heavily qualitative data pertaining to functional requirements of the prototype was purposively collected from subject matter experts who have provided professional medical care to diabetics for at least five years. Using the Delphi method, the country-specific and diabetes-specific framework was vetted by a panel of experts. The panellists reviewed the framework and ranked the requirements in order of perceived importance. Functions that resulted in a clustered consensus of agreement or disagreement were retained or discarded respectively. Functions retained were related to condition tracking, medication management, test result management, diabetes education and appointment management. The vetted framework informed the design and development of a web application prototype simulating Electronic Medical Record-Personal Health Record integration.

With respect to interface design, Shneiderman's Eight Golden Rules of Interface Design and elements from Google's Material Design guided the application's frontend creation. While this was not a usability study, it was necessary to produce a successful user interface to prevent negative evaluation feedback resulting from poor user experience rather than the integration of the systems. Subsequent to development, over the course of two weeks, forty-three diabetics registered at public healthcare facilities in Guyana were exposed to the prototype in a controlled testing environment to measure their acceptance of the system and its transformative potential. The integrated Technology Acceptance Model and DeLone and McLean Information Systems Success Model was used. The dimensions considered for evaluation were behaviour intention, information quality, perceived ease of use, perceived usefulness, service quality, system quality and user satisfaction. The diabetic participants, selected through convenience sampling, were evaluated in focus groups ranging from three to five members. The system was described to the participants and then a guided demonstration was conducted. At the end of this process, the participants were individually interviewed using survey questions that corresponded to the integrated Technology Acceptance Model and DeLone and McLean Information Systems Success Model.

Prolonged independent use of the system followed by evaluation would have contributed to a more realistic testing environment. However, ethical concerns limited the study to this controlled exposure followed by immediate testing. Cronbach's alpha was used to statistically determine the consistency of individual responses for each model dimension evaluated. It was found that the data collected supports the usefulness of the system and shows extremely high user acceptance of the technology – with privacy concerns being the most limiting acceptance factor. This may be a result of the evaluation demonstration that focused primarily on the prototype's functional requirements. If security mechanisms were better emphasised, trust and privacy concerns may not have been a hindrance to technology acceptance.

This study has contributed to the existing body of knowledge by generating empirical data that quantitatively supports the use of this technology. The in-depth study of the technological model within a specific population and context provided a research environment where theoretical concepts could be tested and refined. However, further

research involving a wider stakeholder demographic and a larger sample size would lead to more conclusive results and insights. With respect to future research, this study has laid a foundation for assumptions to be made about similar populations. It has also contributed a researched testing prototype and framework that can be modified and adapted for studies related to domain-specific integrated health information systems.

Keywords: *Health Information Systems, integration, Electronic Medical Record, Personal Health Record*

References:

Detmer, D., Bloomrosen, M., Raymond, B., and Tang, P. (2008), "Integrated personal health records: transformative tools for consumer-centric care", *BMC Medical Informatics and Decision Making*, Vol.8, No.1, pp.45.

Grant, R. W., Wald, J. S., Schnipper, J. L., Gandhi, T. K., Poon, E. G., Orav, E. J., and Middleton, B. (2008), "Practice-linked online personal health records for type 2 diabetes mellitus: A randomised controlled trial", *Archives of Internal Medicine*, Vol.168, No.16, pp.1776-1782.

Authors' Biographical Notes:

Alicia Layne *is an Instructor in the Department of Computer Science at the University of Guyana. Her undergraduate research explored the transformative potential of integrating health information systems. She is currently investigating the application of data science techniques to extend this work.*

Malcolm Williams *is a Lecturer in the Department of Computer Science at the University of Guyana. He currently teaches computer science and information systems at the undergraduate level. His research interests are in the areas of Information Systems, IT Governance, ICT Project Management, Technology Adoption and eGovernment.*

Roland Daynauth *is a Lecturer at the University of Guyana in the department of Computer Science. He previously served as a lecturer in the department of Mathematics, Physics and Statistics at the University of Guyana from 2007 to 2015. Mr. Daynauth holds a Bachelor's Degree in Mathematics from the University of Guyana, a Masters Degree in Computer Science from the University of the West Indies and a Masters Degree in Data Science from the Heriot-Watt University. His previous research looked at the use of semantic technologies for effective management of glucose levels for patients with type 1 diabetes.*

■

An Investigation of Cognitive Overload and Reaction Time in Mobile Augmented Reality Environments

Amrita Ramnauth[1] and Penelope G. DeFreitas[2]

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
[1]Email: amy_ramnauth@yahoo.com;
[2]Email: penelope.defreitas@uog.edu.gy;

Abstract: *Augmented reality brings a modern approach of dynamically presenting content to end users; however, the nature of the technology can result in users feeling overwhelmed by the amount of information flooded to their device, which is commonly referred to as cognitive overload. Furthermore, there are no defined standards for designing Mobile Augmented Reality (MAR) applications, thus the condition of cognitive overload remains an issue until trial and error cases are explored to see what works best for such environments. After employing filtering strategies, which fundamentally presented copious amounts of content in a manageable way, the existential cognitive overload problem encountered by MAR applications was addressed. Three filtering techniques, mirroring menu systems, were used for presenting content to end-users: a category-based filter utilising icons and a colour-coding mechanism for association, a checklist filter for grouping multiple options under an umbrella category and a quick guide filter which chunked content. Testing was conducted at the Faculty of Natural Sciences, University of Guyana campus and involved 22 individuals who were unfamiliar with the environment. Out of the three filtering strategies, the checklist approach resulted in the least reaction time and presented the least cognitive overload for end-users, highlighting the need for a filtering technique that allows direct manipulation over what is perceived in the environment.*

Keywords: *Mobile augmented reality, cognitive overload, reaction time, user interface, design considerations*

Authors' Biographical Notes:

Amrita Ramnauth *is a software engineer, working towards simplifying complicated workflows at a local startup, IntellectStorm Inc. She recently read for her Bachelor's Degree in Computer Science at the University of Guyana. Her research interests are in the areas of computing technologies, systems engineering and application development.*

Penelope G. DeFreitas *is a lecturer in the Department of Computer Science, at the University of Guyana. She holds a post graduate diploma in Education from the University of Guyana and a Master's Degree in Computer Science from the University of the West Indies, Mona campus. Her main research interests lie within the areas of E-Learning and Human Computer Interaction.*

■

VisC - A Visualisation Tool for Learning Fundamental Programming Concepts

Dave U. Sarran[1] and Lenandlar Singh[2]

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
[1]Email: dave.sarran@uog.edu.gy;
[2]Email: lenandlar.singh@uog.edu.gy;

Abstract: *The learning of computer programming is a challenge for novices and beginnings and remains one of the outstanding problems in Computer Science Education. Programming is a complex task that requires the development of multiple skills including logical and computational thinking in addition to learning programming language syntax. Many studies have explored the development of software tools to help students learn programming but with varying levels of success. In this study we designed and evaluated a tool to assist beginners develop programming skills via visualisation. We explored and described fundamental syntax-related, logic and debugging issues faced by beginner programmers during the early stages of a programming course. Our motivation behind this research is to explore the impact of visualisation and visualisation systems on resolving these programming-related issues. The research goals we explored are: 1) identification of the fundamental areas of programming where beginners experience learning issues, 2) analysis of gaps and weaknesses in previously designed visualisation systems that supports the learning of programming, and 3) development of a visualisation system that employs visual techniques of learning that attempts to fill the gaps in other systems. Through identification of the gaps in the literature our visualisation tool is designed with three features to support learning: (1) source code examples (2) a forward and backward stepwise process and (3) dynamic graphics and animations.*

To evaluate this tool, we used a single group design with pre-test/intervention/post-test method and a sample of 66 year-one Computer Science students. Participants were administered a pre-test developed by the researchers and comprising programming questions to establish a baseline measure of students present understanding of programming concepts. The instrument tested the concepts of variables, incremental operations, conditional statements and loops. These concepts were implemented in the visualisation tool. All students were then administered the visualisation tool in a laboratory session to further explore these concepts. Students were then administered a post-test instrument with concepts similar to those in the pre-test. In addition, a survey was administered to users to obtain feedback about their experience with the tool and about the perception of it to aid learning.

Using repeated measured matched pairs t-test, we observed significant improvement in students test scores on all matching items for the concepts tested – variables, incremental operations, conditional statements, and loops. To explore students' perception and experience using the tool, we surveyed students. The results of this survey suggested the tool's visual techniques helped students learn the programming concepts presented. They noted the single-stepping feature enhanced their understanding as it allowed them to control the display of visuals and that the manual forward and backward stepping feature gave them maximum control. Further, they reported enjoyed viewing the execution of code examples one line at a time along with the accompanying visual explanations. Students particularly valued the back-stepping feature through source code when they did not initially grasp the intended visual explanation. Overall, the forward and backward stepping, auto-running through source code coupled with the environment in which visuals were displayed provided an effective learning space for students.

This study suggests that visualisation is a viable pedagogical approach in teaching fundamental programming concepts when the visualisation allows students to step through source at their own pace and when students can step backward and forward through source code. However, this study should be repeated using an experimental design with a control group to further investigate its utility in helping student to learn programming concepts.

Keywords: *Computer Science Education, Programming, Visualisation, Source Code Example*

Authors' Biographical Notes:

Dave Sarran *is a lecturer in the Department of Computer Science at the University of Guyana. He currently teaches computer science, information technology and information systems at the undergraduate level. His research interests are in the areas of Information Systems and Computer Science Education.*

Lenandlar Singh *is a Senior Lecturer in the Department of Computer Science at the University of Guyana. He teaches computer science at the undergraduate level and information systems at the graduate level. His research interests are in the areas of Human Computer Interaction (HCI), Learning Technologies, Computer Science Education and Information Systems Design and Development.*

■

Unlearning Learned Helplessness: A Computerised Cognitive Behavioural Therapy Approach

Juanelle Marks[1], Malcolm Williams[2], and Aurell Liddell[3]

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
[1]Email: juanelle.marks@uog.edu.gy;
[2]Email: malcolm.williams@uog.edu.gy;
[3]Email: aurel.liddell@uog.edu.gy;

Abstract: *In classrooms the world over, some students react in a mastery-oriented manner when they fail at challenging tasks, while others become turned off. The latter reaction is known as learned helplessness. In this design science research study, a prototype computerised cognitive behavioural therapy (CCBT) tool that incorporates principles of Pavlov's Theory of Classical Conditioning, Achievement Attribution Theory and the Learning Goals approach was built and evaluated to determine the extent to which it aids in the unlearning of learned helplessness. An evaluation, in the form of a longitudinal study, was conducted with a randomised purposive sample of thirty students. A combination of quantitative and qualitative measures was used in this study. A pre-test measured the learned helpless traits in the sample following which the participants interacted with the tool for a period of two weeks, while being observed by the researcher. A post-test was conducted thereafter. The results revealed a statistically significant difference in the learned helplessness traits exhibited by students before and after the intervention. This difference indicates that the tool has a positive effect on the unlearning of learned helplessness among the sample. The findings suggest that use of the tool can help students to overcome their fear of failure in relation to classroom activities.*

Keywords: *Learned helplessness, learning goals, classical conditioning, achievement attribution theory*

Authors' Biographical Notes:

Juanelle Marks *is an Instructor in the Department of Computer Science at the University of Guyana where she currently teaches computer science at the undergraduate level. Her research interests are in the areas of Data Science, Learning Technologies and Computer Science Education.*

Malcolm Williams *is a Lecturer in the Department of Computer Science at the University of Guyana. He currently teaches computer science and information systems at the undergraduate level. His research interests are in the areas of Information Systems, IT Governance, ICT Project Management, Technology Adoption and eGovernment.*

Aurell Liddell *is a Lecturer in the Department of Computer Science at the University of Guyana. She currently teaches computer science, information technology and information systems at the undergraduate level. Her research interests are in the areas of Information Systems Design and Development, eLearning Technologies and Computer Science Education.*

■

Promoting Computer Science Education in a Developing Country: Experiences from 'Code Camp Guyana'

Juanelle Marks[1], and Lenandlar Singh[2]

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
[1]Email: juanelle.marks@uog.edu.gy;
[2]Email: lenandlar.singh@uog.edu.gy;

Abstract: *Computer Technology is one of the fastest growing areas of development globally. This dynamic growth has forced education systems to respond to meet increasing demands for skills and so there is more emphasis to integrate digital literacies, computational thinking and programming into the curriculum. In some countries, especially those that are developed, the integration of these literacies into the school's curriculum is ongoing with a significant increase in the number of schools that expose school-aged children to computer science education. However, in developing countries such as Guyana, the integration of computer science education into the national curriculum is slow-paced or absent altogether. One contributing factor to this problem is low emphasis on computer science as the curriculum in many secondary schools focuses mainly on Information Technology and Electronic Document Preparation and Management.*

To narrow the gap of access to computer science education opportunities in Guyana, several initiatives were developed by various organisations in Guyana including the Ministry of Public Telecommunications (MOPT). One of these initiatives is the 2018 MOPT Code Camps. This camp was developed to stimulate interest in computer science and targeted 120 primary and secondary school aged students across three counties in Guyana. The content of this code camp was developed and facilitated by the researchers. This five-week code camp introduced students to Web Design and Development using HTML and CSS, Physical Computing using BBC Micro:bit, Programming and Data Management using Python, and Computer Graphics using Processing. In this paper, we share our experiences developing and executing the code camp for the MOPT. Each of the four modules was taught for approximately five to seven days and for three hours per day.

An evaluation of the experiences of instructors and students was conducted to better understand the impact, outcomes and challenges of this code camp. We use a participant-observer methodology together with surveys and interviews to tease out important lessons learned. Instructors and teaching assistants were sent a questionnaire designed by the researchers via email. Students were engaged using a semi-structured interview developed by the researchers. The researchers who were active participants of this code camp also reflected on their experiences with the code camp using autoethnography and through note-taking and journaling of important observations during the code camp.

Results from the critical autoethnography indicated that students developed many artefacts over the course of the code camp. For example, students developed websites using HTML and CSS, computer games and graphical programs using Processing, and various physical computing artefacts using the BBC Microbit. However, the researchers noted that many students struggled with the Python programming module and were not able to sustain the same levels of output and rate of learning as they did in previous three modules. The instructors reported that the Python module presented a higher cognitive demand on students and that students were generally not as excited about text-based programming provided by Python. Students noted this exposure to computer programming was a novel experience for them and they were very enthused about their newly formed competencies. One challenge experienced is the steep learning students encountered because of lack of prior knowledge. However, over time we recognised the development of computational thinking skills as they successfully developed websites and other artefacts.

The results of this evaluation can serve as a good guide for policy makers and educators who are interested in providing out-of-school computer science experiences and opportunities for students in the developing world context. This study provides valuable insights into the types of activities students find interesting and those that are challenging.

Keywords: *Computer Science Education, Programming, Code Camp, Development, Developing Country*

Authors' Biographical Notes:

Juanelle Marks *is an Instructor in the Department of Computer Science at the University of Guyana. She currently teaches computer science at the undergraduate level. Her research interests are in the areas of Data Science, Learning Technologies and Computer Science Education.*

Lenandlar Singh *is a Senior Lecturer in the Department of Computer Science at the University of Guyana. He teaches computer science at the undergraduate level and information systems at the graduate level. His research interests are in the areas of Human Computer Interaction (HCI), Learning Technologies, Computer Science Education and Information Systems Design and Development.*

■

The Use of Keystroke Dynamics as the Primary Basis of Authentication

Kwesi Elliot[1], Dave Sarran[2], Lenandlar Singh[3], and Troy Thomas[4]

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
[1]Email: kwesishar@yahoo.com;
[2]Email: dave.sarran@uog.edu.gy;
[3]Email: lenandlar.singh@uog.edu.gy;
[4]Email: troy.thomas@uog.edu.gy;

Abstract: *The use of alpha-numeric passwords is the most popular authentication method employed today in computer systems. Passwords are widely used because they are simple and a relatively cheap means of authentication. According to a study conducted by Verizon in 2017, approximately 81% of all data breaches in the year 2016 was as a result of either stolen and/or weak passwords. Alternative methods of authentication are therefore needed. Biometrics such as fingerprint scanning offers potentially more reliable forms of authentication, but they generally rely on additional hardware which invariably means additional cost. In this study, we explored users typing rhythm on the keyboard as an alternative authentication mechanism. We explore this approach as a secure cost-effective method of authentication since it requires the use of the keyboard which is usually available with a standard computer system. Users were authenticated based on three keystroke criteria: duration the user holds each key for; the interval between letters typed; and the time interval between typing letters in one's name. A user was required to be successful in all three areas to successfully authenticate. A software was developed to capture the required data as the user typed as well as to authenticate the user.*

To test the model developed, 17 students and staff of the University of Guyana were selected to participate in the study. They were asked to type their first name and a selected sentence (test case) 10 times. The time each letter was held down by a user while typing was recorded along with the time interval between presses of consecutive letters. The data generated was stored in text files and used as a reference signature for authentication. The users were then asked to authenticate 10 times. To authenticate, the user was asked to type their first name once and the test case sentence. The time interval between successive keystrokes and the time each character each letter was held down for while being pressed was recorded. The average time between keystrokes when typing one's name during the registration phase was compared with the time between successive keystroke when typing one's name during the authentication phase. A correlation was performed to determine if the user would have successfully authenticated. A correlation of greater than 0.5 was determined to be success for this study

The second phase of authentication involved comparing the held time of characters during the registration phase with those during the authentication phase. The held time of all the characters typed during the registration phase was read from the text files and stored in linked lists. The average held time of each letter was calculated and compared with the average held time of each character typed during the authentication phase. The percentage difference between what was stored during the authentication phase and that which was typed during the authentication phase was calculated for each letter. An overall average percentage difference was calculated. A percent difference of less than 25% was considered a success for this study.

The third phase involved the use of digraph timings. Eight digraphs were selected to create a reference during the authentication phase. Those diagraphs used are the in,io,no,on,ul,is,ad,ef digraphs. The in,io,on,no were selected because they were found in a previous study to help with improved performance when only those digraphs were used. The average time interval between successive keystrokes when typing these digraphs were calculated and compared with that obtained during the authentication phase. The percentage difference between that obtained during the registration phase was compared with that obtained during the authentication phase. A percent difference of less than 25% was considered as success.

In order to successfully authenticate, the user should achieve success in all three areas at authentication. In our evaluation of the system we used a total of 153 users. Of the 153 attempts by users to authenticate, 41 attempts were successful. There were 55 attempts by users to authenticate as someone else with none of those attempts being successful. This translates to a false acceptance rate of 0% and the false rejection of 73%.

The major success of this project was the false acceptance rate of 0%. This demonstrates that the use of keystroke dynamics as a means of static authentication is potentially useful and should be explored further. With a

false reject rate of 73%, the system did not perform as expected. This shows that on average, one would need to attempt to authenticate 3 times before being recognized as the authentic user when logging in to his/her own account. Further research to reduce this rate down to a more acceptable level is recommended. This system also demonstrates how difficult it is for users to mimic someone else's typing pattern. When compared to other studies that only used a single parameter to authenticate users, the use of multiple parameters is seen as much more reliable in keeping out imposters and illegal users.

Keywords: *Security, Authentication, Keystrokes, Biometrics*

Authors' Biographical Notes:

Kwesi Elliot *is a prospective graduate at the University of Guyana. He has successfully completed all the requirements for the Bachelor of Science in Computer Science with distinction. His interests are in information assurance and computer security.*

Dave Sarran *is a lecturer in the Department of Computer Science at the University of Guyana. He currently teaches computer science, information technology and information systems at the undergraduate level. His research interests are in the areas of Information Systems and Computer Science Education.*

Lenandlar Singh *is a Senior Lecturer in the Department of Computer Science at the University of Guyana. He teaches computer science at the undergraduate level and information systems at the graduate level. His research interests are in the areas of Human Computer Interaction (HCI), Learning Technologies, Computer Science Education and Information Systems Design and Development.*

Troy Thomas *is the Director of Undergraduate Research at the University of Guyana. He holds a PhD in Comparative Science of Cultures with a focus on survey methodological issues from the University of Ghent. For some time now, he has been involved in research on response styles in surveys with a focus on methods for and approaches to measuring and correcting for response styles while analysis survey responses. At the University of Guyana, he teaches mathematics and statistics in the Department of Mathematics, Physics and Statistics and collaborates across faculties to deliver courses such as Biostatistics at the graduate level.*

■

A Model to Support the Development of Undergraduate Research in Computer Science

Lenandlar Singh

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
Email: lenandlar.singh@uog.edu.gy;

Abstract: *Undergraduate research in becoming an increasingly important part of the students experience at Universities and Colleges. Computer Science and related disciplines have been exploring research with undergraduate students for many years using a plethora of approaches. Some of these approaches are formalised as capstone projects while others focus on student's participation in research projects using a less-structured approach. Regardless of the approach, there remains a paucity of research on strategies for effectively supporting undergraduate research.*

This paper describes a model that is being developed and piloted by the Department of Computer Science at the University of Guyana. It uses a mixed method approach involving literature review, autoethnographic reflections of undergraduate research supervisors and surveys with students to explore the effectiveness and challenges of the model. The literature review element of this study identifies successful approaches to supporting undergraduate research and specifically the domain of computer science. The autoethnographic aspect provides reflective assessment of the process by members of the undergraduate research management and supervision team. This autoethnography is done using an open-ended questionnaire developed by the researcher. A student survey using an online questionnaire and administered to students who completed research projects in the year 2018/2019 provides the data to evaluate students' experiences.

In summary this model is built around two (2) core courses: (1) proposal development, (2) research project. Each of the two courses is supported by a coordination team that manages the administrative and logistics elements of the course. In terms of content, each course is delivered using a range of presentations and seminars that focuses on elements of the research process such as proposal writing, literature review, research methods, systems evaluation, and data analysis. In addition, students are required to present all aspects of their research in stages commencing with proposal presentation and problem defence, literature review, artefact development and evaluation, data analysis and results. All students are required to deliver a final presentation of their research. Unique to all of these activities is the shared assessment and evaluation by all staff of the department of computer science, including supervisors. There is also blind second-marking of all theses to further improve the quality of assessment.

Preliminary results of the evaluation of this model suggest that the model has been efficient in supporting the development of research skills required by students to successfully undertake research projects. In addition, staff and students have indicated that the level of support built into the model is among its most important feature. Students responded positively to the various elements of the research process such as the literature review and data analysis sessions. Staff believe that this modular approach to supporting undergraduate research in computer science have raised the level of outcomes and the standards of students' projects. Further indicators of the utility of this model are indicated by the increasing number of conference presentations and journal articles resulting from students' research projects. There is also some early indication that students are being accepted into postgraduate studies largely because of their undergraduate research experience. However, some challenges remain such as the amount of time allocated for various activities indicated in the model and the level of supervision and these are being reviewed as the model undergoes further refinement.

The results of this study can inform educators and researchers in supporting undergraduate research computer science. By focusing on the research process in detail this model provides insights about good practices, challenges and opportunities for improving the research experience of undergraduates.

Keywords: *Undergraduate Research, Computer Science, Computer Science Education*

Author's Biographical Notes:

Lenandlar Singh *is a Senior Lecturer in the Department of Computer Science at the University of Guyana. He teaches computer science at the undergraduate level and information systems at the graduate level. His research interests are in the areas of Human Computer Interaction (HCI), Learning Technologies, Computer Science Education and Information Systems Design and Development.*

■

An Exploration of Users' Perspectives on Software Updating Message Design

Neil Balram[1], Aurel Liddell[2], and Lenandlar Singh[3]

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
[1]Email: neil.balram@yahoo.com;
[2]Email: aurel.liddell@uog.edu.gy;
[3]Email: lenandlar.singh@uog.edu.gy;

Abstract: *Computer Software typically undergoes a multitude of updates over time to remain useful and functional. These updates may include the addition of new features, removal of outdated features, the application of security patches and modifications to the user interfaces. If users prolong the process of updating their software, it can have serious implications for their computer. This means that choosing to not update your application software will ultimately affect usability, security and compatibility with other software. However, users may neglect the installation of software updates due to several reasons including the usability of update interfaces. In improving the number of software updates performed on a large scale, studies were conducted on both the software updating process and the software updating warning message design; however, limited research literature was found on the design of the user interface in the software update message design. In this study, users' reactions and responses to the software updating message design were investigated to identify the factors that prevent users from applying software updates on their personal computers and subsequently maximize the number of successful updates through improved users' experiences. We also hypothesised that well-designed software update interfaces will improve the software-update experience of non-technical users.*

We approached this study following usability testing and evaluation methodology. To better understand users' software update practices and to identify usability issues, we analysed four (4) commonly used software message designs. This analysis guided the design of two (2) custom-designed update interfaces categorized as the Tabular Design and the Windows Motivated Design. In addition to the liked features of the existing software update screens, the new custom-designed interfaces included features to capture the update's priority level, installation size, time required to update and users' choice of scheduling update for a more convenient period. The Tabular Design interface took advantage of the cognitive contrast between dark and light colours which is argued to better distinguish different sections of the update screen. However, the Windows Motivated Design employs the key design features of the Windows 10 Update Screen to mimic its simplicity and modern looks along with multiple improvements. To test and validate the users' preferences in the two (2) newly designed update screens, a software update manager was developed and deployed to the sample of participants to manage all of their software updates from a central location, and for them to provide feedback on the software update screens utilized in the system. Unique to this update manager is the user's preference of a software update design - the user is prompted to select the design of preference to interact. We evaluated the existing interfaces and our new designs on the following parameters: user perception, prior experience and general usability principles. Our evaluation used three approaches: a qualitative study to identify preferred design features for users; a quantitative assessment to reveal relationships between users' personalities and the updated design; and a comparative analysis on the selected group of users' choices towards software updating message designs.

Participants were asked to evaluate the software design interfaces in a number of contexts, most of which had specific purposes such as the 5-Second Test, Think-Aloud Protocol and the Heuristic Evaluation. Results show that the tested software updating screens clearly communicated their purpose. However, there was some indication that there can be further improvements to benefit users. For example, the most commonly disliked features of the updating screens included: the lack of understanding of the update; the organization of information on the screen; the time required to install; the installation size; the limited range of options on the screens; the design of action buttons; and the use of terminology for action links. In addition to the mentioned disliked features, some participants questioned the choice of colours, size of the update screen, the relevance of the content included in the message dialog, font colours and positioning of text in the updated design.

User experiences can also be improved by increasing the individual's confidence, maximizing the user's comfort and targeting a positive emotional experience from the software updating designs. Patterns in the qualitative data analysed indicated that users' emotions are an important psychological factor to consider when dealing with software updates. It is theorized that users' positive emotions towards an update screen or the software

brand itself can ultimately increase the likelihood for the software being successfully updated by the user. To identify the emotions portrayed towards update screens, users were presented with Plutchik's Wheel of Emotions on the eight basic emotions of anticipation, fear, surprise, disgust, joy, sadness, anger and trust. We found that that users experienced most positive reactions of trust, joy, anticipation and surprise for the Windows Motivated Design, however, they experienced a higher level of disgust and anticipation for the Tabular Design. Based on the overall preference of software update designs and the emotions revealed respectively, developers and designers can target gaining the emotions of anticipation, trust and joy from end-users in an attempt to increase the users' experiences.

By comparing existing software update screens with two custom design prototypes in this research, we provided additional insights on the relationship between the update screen designs to different users; the users' understanding of software updates; the cognitive effects of software updating screens and the tending of users rejecting to update their software. Our findings suggest that designers and developers must pay more attention to the user's preferences in the software update interfaces, especially those that may be critical to the user's system. Ultimately, well-designed software interfaces must incorporate the users' preferred design features and properly structured information on the screen whilst aiming to provide users with positive emotional experiences.

Keywords: Software Updates, Message Design, User Experience

Authors' Biographical Notes:

Neil Balram *is an alumna of the Department of Computer Science, Faculty of Natural Sciences with a Bachelor's of Science Degree in Computer Science of distinction honours from the University of Guyana. His research interests are focused in the areas of Computational Sciences, Human-Computer Interaction, Software Development and Data Analysis. In addition to his academic pursuits, Neil is a software developer at the Caribbean Community (CARICOM) Secretariat.*

Aurel Liddell *is a Lecturer in the Department of Computer Science at the University of Guyana. She currently teaches computer science, information technology and information systems at the undergraduate level. Her research interests are in the areas of Information Systems Design and Development, eLearning Technologies and Computer Science Education.*

Lenandlar Singh *is a Senior Lecturer in the Department of Computer Science at the University of Guyana. He teaches computer science at the undergraduate level and information systems at the graduate level. His research interests are in the areas of Human Computer Interaction (HCI), Learning Technologies, Computer Science Education and Information Systems Design and Development.*

■

Advancing Undergraduate Research in the Disciplines: Insight and Ideas from the University of Guyana

Pamela Rose[1], Troy Thomas[2], and Lenandlar Singh[3]

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
[1]Email: pamela.rose@uog.edu.gy;
[2]Email: troy.thomas@uog.edu.gy;
[3]Email: lenandlar.singh@uog.edu.gy;

Abstract: *In the North American context, universities have established alliances to create innovative approaches to undergraduate research across all disciplines. One alliance is the National Council on Undergraduate Research (NCUR) that provides opportunities for students and their mentors to benefit from high-quality original research experiences. Drawing from this approach, the University of Guyana recently established an Office for Undergraduate Research to increase opportunities for undergraduate research and scholarship across disciplines. This paper provides insights into institutional efforts to implement the Office for Undergraduate Research and explores ideas for a Caribbean undergraduate research council.*

Keywords: *Undergraduate research, disciplines, research council*

Authors' Biographical Notes:

Pamela Rose *is associated with the Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America.*

Troy Thomas *is associated with the Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America*

Lenandlar Singh *is a Senior Lecturer in the Department of Computer Science at the University of Guyana. He teaches computer science at the undergraduate level and information systems at the graduate level. His research interests are in the areas of Human Computer Interaction (HCI), Learning Technologies, Computer Science Education and Information Systems Design and Development.*

■

The Perception of Electronics Waste Management and Disposal Practices in Guyana

Penelope G. DeFreitas

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
Email: penelope.defreitas@uog.edu.gy;

Abstract: *Electronic manufacturing and consumption is a booming industry. At the same time the lifespan of electronic gadgets has shortened significantly leading to a rapid cycle of manufacture-purchase-replacement. To compound this issue, the frequency at which newer models are released entices consumers to keep abreast with the latest trends. As a result, these habits have led to increased levels of electronic waste. This study explores the perceptions and practices of Guyanese regarding the issue of electronic waste. The objectives of this research are to determine whether Guyanese perceive electronic waste management to be an issue. In addition, this study evaluates the effect of electronic waste on the environment, and explores the current disposal and recycling practices. This study uses data gathered from various stakeholders: citizens, companies within the public and private sector, environmental agencies using surveys and interviews. Preliminary results indicate that the management of e-waste is ad hoc at best. The results of this study will help to inform policy makers on e-waste management and will lead to improved electronic waste management practices.*

Keywords: *Electronic Waste, environment, recycling, waste management*

Author's Biographical Notes:

Penelope G. DeFreitas *is a lecturer within the Department of Computer Science, at the University of Guyana. She holds a post graduate diploma in Education from the University of Guyana and a Master's Degree in Computer Science from the University of the West Indies, Mona campus. Her main research interests lie within the areas of E-Learning and Human Computer Interaction.*

■

First Time Experiences of Females Programming at the Grade 6 to 9 Level

Penelope G. DeFreitas[1], and Alicia Layne[2]

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
[1]Email: penelope.defreitas@uog.edu.gy;
[2]Email: alicia.layne@uog.edu.gy;

Abstract: *Over the last decade, the intake rates of female students within the Department of Computer Science at the University of Guyana (UG), has been predominantly low. This fueled an increased number of school outreach projects to sensitize females within the school system, on the advantages of the Information Communication Technology (ICT) field and the need for females to pursue careers in this area. This study stemmed from collaborative efforts between UG and the Ministry of Public Telecommunications, Guyana as an endeavour to educate and attract more females to the field of ICT. We examined the perceptions held by female students towards programming, which is key to ICT. This cohort comprised 56 female students from grades 6 to 9. These students aged 11 to 15 years old and had little or no prior knowledge of programming. They were exposed to fundamental concepts of how computers work, as well as techniques for designing and developing computer software over a twelve-week period. The training sessions included a mixture of theoretical and practical activities to engage the students as they learnt new concepts. The practical activities were introduced using two main tools: Scratch and BBC micro:bit. Using surveys and participants observations, the researchers observed that the students expressed immense enthusiasm towards the practical activities. In addition, working in pairs coupled with incentives, goals and challenges, resulted in a higher chance of success. Students' initial perceptions of ICT being boring had changed after the initial sessions. A major takeaway for the group was that the training was unlike any they had experienced, and they look forward to the advanced level course.*

Keywords: *Programming, females, ICT, Scratch, BBC micro:bit*

Authors' Biographical Notes:

Penelope G. DeFreitas *is a lecturer within the Department of Computer Science, at the University of Guyana. She holds a post graduate diploma in Education from the University of Guyana and a Master's Degree in Computer Science from the University of the West Indies, Mona campus. Her main research interests lie within the areas of E-Learning and Human Computer Interaction.*

Alicia Layne *is an instructor at the University of Guyana within the department of Computer Science. In 2017, she received her Bachelor's Degree in Computer Science from the University of Guyana. Her undergraduate research explored the potential impact of integrating health information systems to improve condition management for diabetics in Guyana. In 2017, this research was accepted by the University of Guyana's Undergraduate Research Conference and the McNair Scholars Conference. For the past four years, Alicia has been actively involved in various Girls In ICT initiatives and is currently interested in conducting gender-based studies in computing education.*

■

The Importance of a National Approach to Cyber Security in a Knowledge-based Economy

Sandra Khan[1] and Malcolm Williams[2]

Faculty of Natural Sciences, Department of Computer Science, University of Guyana, Guyana; South America;
[1]Email: Sandra.Khan@uog.edu.gy;
[2]Email: Malcolm.Williams@uog.edu.gy;

Abstract: *CARICOM States are already heavily reliant on Information and Communication Technology at all levels of society. This trend will only continue to increase in Guyana as the Oil and Gas industry makes its imprint on the society. While cybercrime and cyberespionage are on the rise globally, the Government of Guyana is grappling with the issue, as is evidenced by the introduction of Cyber Crime Legislation, on one hand, but they have not yet invested in training of Prosecutors and the Judiciary, on the other hand. Internationally, there is a trend towards the creation of National Cyber Security Strategies to guide and support the coherent development of an appropriate national policy framework that can adequately support the Cyber Security requirements of nation-states. Cyber Security is now viewed as central to a knowledge-based economy, as a national strategic issue and not merely a computer security issue. A National Cyber Security Strategy is advocated to be an important framework for effective management of cyber security for the prevention of misuse of a nation's critical information infrastructure.*

This research uses a qualitative case study approach to investigate the validity of the claim of the importance of a National Cyber Security Strategy to effective management of a nation's cyberspace. We use participant observations, interviews and publicly available reports and documents to compare the internationally recommended National Cyber Security Strategy approach to the approach taken by the Government of four CARICOM nations as they attempt to cope with the misuse of cyberspace. The results of this study show that there is already an international knowledge base on the pitfalls that nations can experience as they formulate an approach to dealing with cybersecurity and cybercrime. Two of the four CARICOM nations studied, Trinidad and Tobago and Jamaica, took a strategic approach to dealing with cybersecurity and the solutions that they have implemented have proven to be sustainable. Guyana and Suriname's attempts to deal with National Cyber Security Governance have failed to date. The results of the study suggest that there are several key success factors to successful national governance of cyber security considering the international and multi-stakeholder nature of the problem and the role and responsibilities of Governments. We conclude that the development and implementation of a National Cyber Security Strategy contributes to bringing all the essential stakeholders (private, public sectors, academia and private citizens) together under Government leadership to effectively address this multi-dimensional cyber-security problem. The decision by a Government to develop a National Cyber Security Strategy is an indicator of Government recognition of its role and responsibilities in a knowledge-based society to local and international stakeholders. Leadership from the highest levels of Government is critical to successful national cyber security governance and without this recognition and consequent action within a nation, it means that the cyber security problem remains unmanaged. It therefore follows that a National Approach to Cyber Security is an essential pre-requisite for the development of an effective knowledge-based society. This research posits that the development of a knowledge-based society shall be stymied without an equally important national approach to the cyber security problem.

Keywords: *National Cyber Security Strategy, Knowledge-based society, Cyber Crime, Cyber Espionage, Cyber Security, Information Security, Critical Information Infrastructure*

Authors' Biographical Notes:

Sandra Khan *is an Information Systems professional with over twenty years of professional experience in Guyana and the region. She served in the capacity as Head, Guyana National Computer Incident Response Team on its establishment by the Government of Guyana (2013 – 2016). She participated during that time in OAS/CICTE regional conferences and symposiums related to Cyber Security. As Head of GNCIRT, Ms. Khan was host of the Guyana National Cyber Security Sensitisation Workshop (2015). Ms. Khan holds an MSc Information Security from Royal Holloway, University of London. She is currently a Lecturer in the Department of Computer Science, University of Guyana.*

Malcolm Williams *is a Lecturer in the Department of Computer Science at the University of Guyana. He currently teaches computer science and information systems at the undergraduate level. His research interests are in the areas of Information Systems, IT Governance, ICT Project Management, Technology Adoption and eGovernment.*

■

Using a Web-based Student Response System to Promote Active Learning in a Classroom Setting

Vineeta Persaud[1] and Rita Persaud [2]

[1]Faculty of Natural Sciences, University of Guyana, Turkeyen, Guyana; South America; Email: vineeta.persaud@uog.edu.gy;

[2] School of Entrepreneurship and Business Innovation,, University of Guyana, Turkeyen, Guyana; South America; Email: rita.persaud@uog.edu.gy;

Abstract: *Various approaches such as teamwork, presentations, and the flipped classroom approach have been used to enhance learning, interaction, and student satisfaction in large classes. This study investigated the feasibility of using a Web-Based Student Response System for large classes at the University of Guyana, and its use in encouraging student engagement and active learning in the classroom. The Web-Based Student Response System, "mQlicker.com" was deployed on an undergraduate class of approximately 120 students for a period of four weeks. During each lecture, students used their portable computing devices to respond to questions about the lecture content. At the culmination of the testing period, a survey was administered to the participants to obtain their opinions of the utility of the system. Data was collected on student understanding of lecture material, level of student participation, and degree of student satisfaction with the use of the Student Response System. The ability to anonymously respond to questions posed by the researchers during lectures encouraged interaction from the class. The majority of the participants in the study claimed to leave the lectures with a better understanding of the material covered in each session. Participants also expressed their enjoyment at seeing others' responses and indicated that they were not afraid to participate due to the anonymity enabled by the system. 97.2% of the participants indicated that their University learning experience could be positively affected if more lecturers adopted the use of similar Web-Based Student Response Systems in the classroom.*

Keywords: *Student response system, active learning, student engagement*

Authors' Biographical Notes:

Vineeta Persaud *is associated with the Faculty of Natural Sciences, University of Guyana, Turkeyen, Guyana; South America.*

Rita Persaud *is associated with the School of Entrepreneurship and Business Innovation,, University of Guyana, Turkeyen, Guyana; South America.*

■

Engineering Nanostructured Ceramics Based on Ancient "Cobalt Blue" Technology

Krystal M. Cunningham[1], Federico Caró[2], and Ioanna Kakoulli[3]

[1]Archaeomaterials Group, University of California, Los Angeles (UCLA), California, USA; Email: kmcunningham4@gmail.com;

[2] The Metropolitan Museum of Art (MMA), Department of Scientific Research, University of California, Los Angeles (UCLA), California USA Email: Federico.Caro@metmuseum.org

[3] Materials Science and Engineering Department, University of California, Los Angeles (UCLA), California, USA; Email: kakoulli@ucla.edu

Abstract: *Archaeological materials and ancient technology not only inform raw material selection and production operation sequences, but also can inspire the chemistry and manufacture of modern materials with improved properties. One such example is a cobalt (Co) aluminum (Al)-spinel pigment, developed and used in Egypt over 3,500 ago, during the New Kingdom (16^{th} to the 11^{th} century BC). This cobalt-based spinel structure produced from natural raw materials and processed at high temperatures, was of great value and was characterized by highly specialized craftsmanship. A spinel has an AB_2O_4 (i.e. $CoAl_2O_4$) structure, consisting of two metallic cations A^{2+} and B^{3+} in tetrahedral and octahedral positions. They have exceptional mechanical properties and ability to perform in high temperature environments. Cobalt blue pigments were produced and used for a very short period of time, mostly during the 18^{th} Dynasty, then suddenly disappeared around the 20^{th} Dynasty (~1100BC). In contrast to the cobalt-containing glasses from Egypt, there are very few scientific studies on the cobalt-based blue pigment and there are still unanswered questions regarding the pigment's chemistry and production method, as well as, the nature and location of the raw materials used: are these pure CoAl-spinel and how where they produced? Did the raw materials include cobalt-rich alums from Egypt? To answer these questions, we apply a multiscale and multianalytical approach based on electron microscopy and X-ray spectroscopies to investigate the relationship between composition, structure and properties of the synthetic pigment. Preliminary results of the paint layer indicated compositional and morphological homogeneity, and interconnecting network of nanocrystals and larger relics with multiple spinel phases present. Also, reproduction experiments are being carried out and results from the mock ups will be used to gain a better understanding on how the paint was produced.*

Keywords*: Spinel, Ceramics, Archaeology, Cobalt blue*

Authors' Biographical Notes:

Krystal M. Cunningham *is a graduate student in Dr. Kakoulli's Archaeomaterials Group, University of California, Los Angeles (UCLA), California*

Federico Caró *is an Associate Research Scientist at the Metropolitan Museum of Art (MMA) in the Department of Scientific Research.*

Ioanna Kakoulli *is Professor at the University of California, Los Angeles (UCLA) in the Materials Science and Engineering Department.*

■

The Global and Local Impact of Road Traffic Injuries. Is it an Epidemic?

Shuvra Dasgupta

Emergency Medicine Division, Department of Surgery, Anaesthesia and ICU
The University of the West Indies, Mona Campus, Jamaica, West Indies; Email: shuvra.dasgupta@gmail.com

Abstract: *Road traffic injuries are the ninth leading cause of death globally, and the principal cause of death among those aged 15-29 years. Road traffic crashes are responsible for over 1.25 million deaths each year, while estimates of the burden of non-fatal injuries range from 20 to 50 million. Half of all deaths on the world's roads are among those with the least protection – motorcyclists (23%), pedestrians (22%) and cyclists (4%). The Jamaican experience has been similar to the global data. In 2017, injury was listed as the third most common cause of premature death in Jamaica. Road Traffic Agency reported 321 fatalities that year, secondary to a road traffic crash. Unfortunately, there is no data on non-fatal injuries. Although road traffic injuries have been a leading cause of mortality for many years, most traffic crashes are both predictable and preventable. Policy makers, safety advocates and drivers all need evidenced base studies showing that the social, economic, and human cost of injury and fatalities from road traffic crashes in Jamaica is far greater than the cost of creating and enforcing injury prevention strategies.*

Keywords*: Road Traffic Injuries, Global and Jamaican data*

Author's Biographical Notes:

Shuvra Dasgupta *is a Consultant and Lecturer at the Emergency Medicine Division, Department of Surgery, Anaesthesia and ICU, The University of the West Indies, Mona Campus. Shuvra has been working at the UWI since 2011. During this time her focus has been to bring emergency medical services (EMS) to the forefront through education, research and clinical intervention. Eventually she hopes that education will bring about policy change in a country where a centralised EMS system is non-existent. She holds a MPH from Johns Hopkins University, majoring in Injury Control and Disaster Preparedness, and a Doctor of Medicine in Emergency Medicine from The University of the West Indies. In October 2018 she was an invited participant of the Young Physician Leaders programme put on by the IAP for Health and also attended the World Health Summit, both in Berlin, Germany.*

■