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Faculty of Science and Engineering (FSE) Research Conference

**Theme: Festival of Research (FoR) and
Research during the COVID-19 Pandemic**

University of Wolverhampton

**Abstracts of papers
presented at the**

**2nd Faculty of Science and Engineering (FSE)
Research Conference
2021**

**Theme: Festival of Research (FoR) and
Research during the COVID-19 Pandemic**

**Hosted by
Dr Subashini Suresh
Professor Amar Aggoun
Professor Keith Burnham
&**

**FSE Postgraduate Research Student
Representatives**

24-25 March 2021



Preface

It is indeed a pleasure to welcome all participants to the 2nd Research Conference organised by the Faculty of Science and Engineering, as we emerge from what might be described as an unprecedented year in which we have all had to adapt ourselves to a new way of working. Consequently, the theme of the Conference is Festival of Research and a celebration of Research during the COVID-19 Pandemic.

Despite the disruption, we have had an excellent response to the call for participation from across our Postgraduate Research Student community, which has resulted in the rich and diverse range of topics included in the book of abstracts. The topics represent a sample snapshot of the current on-going research programmes within the Faculty. With increased emphasis being placed on the impact of our research, it is interesting to witness the wide-ranging areas of investigation, where our research continues to extend and develop new concepts as well as seeking solutions for real-life problems for the benefit of society. The underpinning motivation for many of the research programmes align with the United Nations Sustainable Development Goals, and some of the abstracts address the current COVID-19 pandemic.

We trust that you will find the on-line event to be of value and we look forward to meeting with you all during the presentations and poster sessions.

Dr Subashini Suresh
Professor Amar Aggoun
Professor Keith Burnham
24-25 March 2021

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United Nations SDGs

Report from FSE Conference 2020 on the awareness amongst the delegates of:

- Sustainability
- United Nations SDGs
- Athena SWAN

**Research
Paper
Abstracts**

The Effects of Covid-19 within the Construction Workplace

Mark Stride

Supervisory team: Dr Subashini Suresh and Dr Suresh Renukappa

Abstract: Introduction/ Problem Statement: Covid-19 has brought immediate unprecedented change to many construction companies and their workplaces. The pandemic has drastically changed the way we work, communicate and socialise and therefore this study directly relates to sustainable development goals 3 (Good health and wellbeing) and 9 (industry, innovation and infrastructure). Organisations have had to adapt to new methods of working, having financial, strategic and operation impacts, creating uncertainty for the future of businesses due to the unpredictability within the economic sector.

Research Objective The primary objective of this study is to understand the impact to the construction sector, both operationally and strategically, caused by the rapidly-changing pandemic. The analysis aims to provide a deeper insight to establish how organisations have adapted to understand and adhere to lockdown rules. The information aims to contribute to informing businesses and policymakers on some of the lessons learnt from the management of Covid-19.

Research Methodology To enable an appropriate review of the effects of Covid-19 within the workplace, it was essential that a comprehensive literature review was completed of the UK construction sector, allowing a full understanding of the impact organisations had incurred, any changes that have been made to adapt and what methods are being used to future-proof against future pandemics. Therefore, thematic analysis of the literature review was used to provide a richer understanding enabling adequate results and recommendations to be produced.

Preliminary or Final Results The initial findings found that organisations had to adopt a three-stage strategy to overcome the new dimensional challenge. Firstly, organisations were making immediate quick-fire decisions to allow their businesses to continue operating. Secondly, implementing new policies and procedures to enable staff to return to work safely. Finally, implementing methods to future-proof organisations against future pandemics. Further to this, it was found that organisations are facing more specific workplace challenges which include flexible working, job termination, Industry 4.0, site practices, office workplaces and mental health and wellbeing.

Five C's were produced as recommendations to help the construction industry improve and protect the sector against future pandemics:

- Create a greater working culture and ensure employees can work safely;
- Introduce Control systems to analyse and manage the amount of employees in workspaces;
- Make Courageous decisions by designing and installing increased pre-fabricated materials to help maintain social distancing;
- Combat mental health issues that have increased due to the pandemic;
- Take greater Care of employees, as their health and wellbeing is paramount.

Research Impact This study contributes to the field of crisis management and the effect the Coronavirus pandemic has had on the UK construction sector and methods to be considered for future-proofing business. This information will benefit companies within the construction industry such as consultants', contractors and developers, researchers, government bodies and professional bodies.

Therefore, this provides grounds for further studies within this subject area and provides opportunity to begin a case-study approach involving multiple methods of data collection (e.g. interview, observation, and documentary analysis). Given that the research reported in this paper is a thematic literature review, the results presented are only tentative and of limited value for the purpose of generalisability. Furthermore, the findings of this paper are limited to the UK construction; as such, the level of generalisability outside this context may be very limited. However, we argue that the results obtained are useful to similar developed countries.

Keywords: Pandemic, mental health & wellbeing, innovation, industry 4.0

SDGs: SDG 3 Good health and wellbeing

SDG 9 Industry, innovation and infrastructure

Smart City – Waste Management Systems and Business Models in India: A Review

Nisha Shetty

Supervisory team: Suresh Renukappa, Subhashini Suresh

Abstract Cities around the world are emerging into the idea of smart cities and better urban environment. Increasing urbanisation has resulted in plummeting conditions in developing countries. The world is building smart cities to advance this strategic development and provide better quality of life for citizens. Cities are increasingly working towards ways to use new 'smart', 'sustainable' technologies to improve the life of inhabitants. Smart cities are designed to remediate environmental problems in particular the issue on waste management in major cities. Waste Management is a built-up issue that needs to be better connected with proper planning and execution for smart city services in Indian cities. Built on an integrative review of the literature, this study offers insights into the potential of smart cities and connected communities in facilitating waste management efforts. It follows the three-step methodology of scientific analysis, comparison and synthesis. Different case studies from the Smart City Mission – India are selected for the study and the waste management systems and business models surveyed by the program are analysed, compared and synthesised. The paper understands the business models that are effectively used in the development of smart city services in India. It further studies the different technologies and systems developed for waste management in different Indian smart cities. The study progresses with an analysis of different waste management systems and the technologies used in Indian smart cities and understands the business model development for the same. The research further provides an integrated study with new frameworks and perspectives on smart cities, waste management systems and innovative business models. The paper concludes with the analogy of people participation and authority administration. The effectiveness of technologies in smart cities and the connectedness of ICT in waste management depends on active citizen participation. Building smart cities and being technology dependant can be achieved in harmony with well-established behavioural attitudes of city residents, virtuous administration, constructive leadership together with the implementation of green and smart urban technologies.

Keywords: Smart City, Waste Management, Business Models, technology, sustainability

SDGs: SDG 6 Clean Water and Sanitation

SDG 11 Sustainable Cities and Communities

Evaluation of challenges for sustainable transformation of Qatar oil and gas industry: A graph theoretic and matrix approach

Redouane Sarrakh

Supervisory team: Suresh Renukappa, Subashini Suresh

Abstract Sustainability is becoming an important component of organisations' operations to ensure success. That is why they are implementing sustainability practices within their strategies to ensure a positive impact on their stakeholders, society and environment. Much like the rest of the world, Qatar has introduced a sustainability plan to guarantee its prosperity through its national vision and strategy plans targeting all of its sectors and especially the oil and gas. Due to the limited research available in exploring the readiness of the Qatar oil and gas industry to implement sustainability strategies. This paper sheds light on the challenges that inhibit the implementation of sustainability strategies within the Qatar oil and gas sector. Following a systematic approach, qualitative data collection and content analysis was carried using semi-structured interviews with key industry professional from the Qatar oil and sector to explore the key challenges that their organisations faced when implementing sustainability strategies. Six key challenges hindering the implementation of sustainability strategies within the Qatar oil and gas industry had been revealed: Stakeholders' issues, volatility of price, resistance to change, knowledge and awareness, initial cost and strategic issues. Furthermore, an attempt had been done to quantify these challenges through the use of a systematic approach, the graph theoretic and matrix approach. The results show that strategic issues represent a great challenge for the sector when implementing sustainability strategies. The sustainability implementation index is calculated for the Qatar oil and gas industry to identify the industry's fitness and ability to implement sustainability strategies. Furthermore, the calculated index is useful, since it provides practical information regarding the challenges facing the industry when implementing sustainability strategy. Evaluating the readiness of the Qatar oil and gas sector to implement sustainability strategies is aligned with the seventh Sustainable Development Goal, which is to ensure access to affordable, reliable, sustainable, and modern energy for all. This paper can be of great importance to several parties interested within sustainability issues, seeing that the degree of success for sustainability strategies implementation depends highly on the impact of its challenges.

Keywords: Qatar oil and gas sector, Sustainable development, Sustainability challenges, Graph theoretic and matrix approach.

SDGs: SDG 7 Ensure access to affordable, reliable, sustainable, and modern energy for all.

SDG 8 Promote sustained, inclusive and sustainable economic growth, full of productive employment and decent work for all.

SDG 9 Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

SDG 13 Take urgent action to combat climate change and its impacts.

Current year of study: Fourth year

A review of leading indicator approaches to behavioural based safety.

Isimemen Judith Ejohwomu

Supervisory team: Dr David Oloke, Dr Lovelin Obi & Dr Olugbenga Oladinrin

Abstract The UK government has recently put productivity improvement at the heart of economic development post Brexit. This is a strategy most low resources countries will adapt as part of their post Covid-19 recovery plan. The implication here is that sectors with strong multiplier (GDP contributions) effects like the construction industry with poor safety and productivity records that stem from very high Lost Time Injuries (LTIs) would be under the spotlight. Differentiating between the role of leading and lagging indicators, this study systematically reviews existing literature for evidence of quantifiable leading indicator approaches to behavioural based safety as a precursor to a more productive construction and building services sector. The methods adopted by previous studies are skewed towards quantitative research strategies and with weak evidence. Simulation and experiments are uncommon. Focus is on the construction phase mostly. The dominant laboratories are Hong Kong and Mainland China. There is need for policy makers and regulators to start rethinking the implementation and regulation of behavioural based safety programmes across project life cycles instead of focusing on the construction phase. Future studies should consider adopting a project cycle approach.

Keywords: Behavioural Based Safety, Construction and Building services, Safety leading indicators, Systematic review

SDGs SDG 3 Good Health and Well-being

 SDG 9 Industry, Innovation and Infrastructure

Current year of study: First year

The role of smart cities strategies in managing COVID-19 outbreak: A Knowledge Management Perspective

Wala Abdalla

Supervisory team: Dr Suresh Renukappa, and Dr Subashini Suresh.

Abstract The Coronavirus disease 2019 (COVID-19) pandemic is spreading all over the world and has become an international public health issue, generating a substantial surge in research experiments, government policies, and social media discussions. Cities became hubs for the quick transmission of the pandemic. However, we are fortunate that our current cities are more resilient than ever before. This is due to the increased adoption of smart technologies such as the Internet of Things (IoT), Big Data, and Artificial Intelligence (AI). The ability to manage COVID-19 pandemic is contingent upon the ability to effectively manage its heterogeneous knowledge resources. Therefore, organisations should develop a set of capabilities to allow them to fully take advantage of the opportunities that could be provided by knowledge management (KM). Smart cities strategies and technologies provide significant opportunities in managing knowledge related to COVID-19 pandemic. However, the current literature shows exclusive focus on technology use for applying restrictions and lockdown strategies, while it ignores one of the most critical elements to tackle the virus spread and to inform and enhance decision making – the need to manage knowledge related to COVID-19. Therefore, the aim of this research is to investigate the role of smart cities strategies play in addressing COVID-19 outbreak from a knowledge management perspective. The methodological approach for this study is a systematic review, covering publications on smart cities, knowledge management, and COVID-19. The findings indicate that smart cities, through the advanced deployment of ICT applications represent useful tools and have crucial role in knowledge capturing and sharing. With regard to knowledge capture, they enable knowledge extraction through facilitating data collection and data analysis over various disparate databases (e.g., healthcare databases); searching for real-time information; handling huge unpredicted amount of data; as well as facilitating automatic, quick and accurate management and analysis of large volumes of data. With regard to knowledge sharing, they allow online training, sharing online treatment guideline, and facilitate regular situation briefing and updating, which is critical for better decision making. Managing knowledge related to COVID-19 pandemic has the potential to improve the planning,

treatment, controlling the pandemic, and enhance decision making. However, the managing huge amount of complex, unstructured data and information remains a big challenge for COVID-19 KM initiatives. The study concluded that the ability to capture, use, manage, and share of knowledge will be a crucial element, in both dealing with the current outbreak, and also for effectively planning and preparing for the future. Therefore, systems that enable knowledge sharing and build a continuous communication channel among the various authorities are required. It is recommended that efforts need to be directed towards creating and establishing an open, multi-department dynamic knowledge sharing and monitoring platforms for an effective and efficient use of data and information analytics to facilitate decision makers to take steps for the path of recovery.

Keywords: COVID-19, coronavirus, smart cities, knowledge management, knowledge capturing, knowledge sharing, technology

SDGs SDG 3: Good health and well-being, SDG 11: Sustainable Cities and Communities

Current year of study: Third year full time

Unmanned Aerial Systems and Business Model Interaction

Hamlet David Reynoso Vanderhorst

Supervisory team: Subashini Suresh; Suresh Renukappa; David Heesom

Abstract Unmanned Aerial Systems (UAS) or drones is a novel professional tool capable of increasing workers' productivity. However, its deficiency in knowledge management systems, market side and a specialised manufactured drone have strained its adoption. Therefore, the drones' industry requires a thought-provoking question regarding the suitable business model for drone adoption urgently. After an extensive analysis of the literature, it is found that the application of drone has been based on knowledge management systems (produce an understanding of drones implications); digitalisation (sensor data collection) or mobility (transport goods); services and manufacturing products (different specialised drones). The shareholders involved in the business models are basically policymakers, organisations in a specific sector and the drone manufacturer. However, the awareness for developing the industry for younger generations is based on the continuous interaction between drone manufacturer, industry adoption cases and flexibility in the regulatory environment. Therefore, the aim PhD shows the different aspects of the drone business model from the built environment perspective. A qualitative research approach was used to collect and analyse data from 24 semi-structured interviews in the Dominican Republic.

The primary findings reveal that drone services may stand on a knowledge phase in which drones are tested and implemented according to the demand. After several tests by receiving outsourcing services or just absorbing the risks involved in a drone implementation, the decision is positive imminent on its adoption. However, the demand for the services or tools relies on the field and characteristic of the industries. For instance, in construction, images services are mostly used in contrast to survey or 3D models. In addition, more than 50% of taxation on importing drones make a tough decision for product and services providers to incorporate this technology with a long-term certainty on the device durability in case of any incidents. Recommendations on market expansion in digitalisation standards and specialised guidance on drone for construction and training are suggested to foster innovation.

Keywords: Drone, Business model, implementation, standards

SDGs

SDG 8.3 Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all

SDG 9.2 Built resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation.

Current year of study: Third year full-time

Indoor environment Quality and the methods used to limit the spread of viruses (COVID- 19)

Mustafa Shetaw

Supervisory team: Professor Mohammed Arif, Dr Louis Groh, Dr Amit Kaushik

Abstract In light of the current conditions that the world is going through from the spread of the Corona virus and the great economic recession it caused and the closure of many commercial, industrial and educational centres to limit the spread of the virus and people's fear of contracting it.

Voices have increased calling for a search for radical solutions to reduce infection with this virus, the World Health Organization has published many warning bulletins and recommended the use of some methods to limit the spread of the virus such as face masks, hand sanitizers, social distancing, but all these measures were not sufficient to limit the spread of the virus, Some of governments completely lockdown for the second time for all universities, schools, offices, all closed places that contain human gatherings and most commercial centres. This is to reduce the speed of the virus's spread and limit the number of infections with it.

In this research, we will study how to preserve the internal atmosphere of closed places and reduce the percentage of indoor air pollution, whether it is with bacteria or viruses, methods of treating indoor air.

The most recent methods used to purify indoor air (ventilation).

When studying the causes of any disease, it is imperative that we first know the ways the infection spreads.

It has been shown that, the most important way for the infection to spread is through the adhesion of viruses to aerosols and contact with surfaces contaminated with viruses.

There are many ways to spread the infection, one of the most important of which is air transport. Microorganisms can travel in the air when aerosol droplets form and are released during speech, coughing, and sneezing.

According to recent studies that, these drops remain suspended in the air in an aerosol droplets about five minutes, after that the fall down in the ground.

The size of these droplets may help in determining the distance that the droplets travel when they are generated, and their size also affects the period during which these viruses remain effective for infecting surfaces.

Some physical properties of the indoor environment influence these droplets, such as temperature, relative humidity and airflow characteristics. In addition to the ventilation and air filtration systems used in the building.

Through research in previous studies, it was found that it is difficult to understand the mechanisms of infection spread and it is difficult to understand the dynamics of aerosol droplets in the air under different indoor environmental conditions.

The aim of this research is to increase awareness among users of indoor atmospheres, and to pay more attention to internal ventilation and methods of treating indoor atmospheres, Knowledge of air purifiers and filters that are effective in removing viruses from the air, high-efficiency particulate air filters (such as HEPA, CADR), Incorrect use of ventilation may further spread viruses into indoor space.

Through literary studies, WHO recommendations, practical measurements of ventilation devices used in the Education Building.

Through the obtained results, it was found that replacing old air in a room with fresh air from outside can greatly reduce the chances of people getting infected.

According to Dr Fitzgerald, research shows that bringing in a good amount of fresh air to mitigate and disperse the virus can reduce the risk of infection by 70-80%.

According to GP, Eilir Hughes, the logo should now become (Wearing masks, washing hands, social distancing, and ventilation).

Emphasize the importance of ventilation.

To increase the rate of providing clean air in open air from 3 to 10, i.e. about 30 liters per person, reduces the percentage of pollution indoor and thus reduces the number of disease infections.

The use of good ventilation systems and the renewal of indoor air in the required quantity is able to remove viruses inside the building and maintain the concentration of pollutants at low healthy levels.

Keywords Indoor Air Quality, Ventilation, COVID-19, Filters

Characterisation of Mechanically Alloyed feedstock for Powder Bed Fusion Titanium Silicon Carbide Metal Matrix Composite

Iain Lyall

Supervisory team: Dr Arun Arjunan

Abstract

Background As sustainability becomes more vital with dwindling global resources, outdated manufacturing methodologies are steadily being replaced by refreshingly new processes such as additive manufacturing (AM) that deliver product improvements and use less resources. This research investigates the characterisation of new materials for the AM process and their manufacture.

Aims Within AM, few materials have been developed due to limited knowledge surrounding feedstock development and key process requirements. Within this research a detailed methodology has been developed and demonstrated along with robust results demonstrating a robustness that it is hoped can be applied to other material combinations. The Aim was to shorten the time required to develop new materials. This is a wasteful and costly process that yields limited results.

Method(s) A new method of feedstock production was developed at the university based on the modification of principles around mechanical alloying. Mechanical alloying is a process that cold-works fine metallic powders over extended periods of time, circa 24 to 50 hours to refine grain structure and improve mechanical characteristics such as strength and hardness using impact forces delivered by steel balls within a rotating chamber. Experimentation involved the combination of titanium metal and silicon carbide ceramic powders for 20 minutes in order to embed the hard-ceramic particles around the soft metallic titanium. This would subsequently be used in the AM process. Feedstock was synthesised, demonstrating qualities suitable for the AM process, such as particle size distribution, morphology, rheology, and powder density characteristics.

Results Results demonstrated that the methodology was able to overcome fundamental difficulties in small-batch feedstock production, typically over-producing unwanted powder that requires reprocessing and further increasing carbon imbalances, delivering acceptable blended feedstock that was both homogeneous and exhibiting the required packing density of 50% and above. A small batch of feedstock was produced repeatably and samples were produced and tested. In total a batch of

260g of feedstock was produced across eight experimental blends. Commercial small batch feedstock production would have produced 30Kg of powder for each blend, a total 240kg of powder, costing approximately £80,000.00 and 85% of the material would be destroyed as unusable powder.

Conclusions It was concluded, firstly that the research should be investigated further to analyse the effectiveness with other material combinations such as: titanium and silver for medical applications, copper and silver for thermal applications and copper tungsten for electronic applications.

Secondly, the route principles on which the research was founded of embedding the smaller hard ceramic material onto the surface of the softer metallic material, referred to as Hard/Soft due to the hard particles being combined with softer particles, has spawned three additional routes of investigation:

The combination of materials that are both soft (Soft/Soft).

The combination of that are both hard (Hard/Hard), and

The electroplating of AM feedstock for in-situ alloying.

This is based not only on the success of the methodology and findings but also the characterisation and recognition of its limitations.

Key words: 'Additive manufacturing' 'Mechanical alloying' 'Feedstock' 'Metal matrix composites' 'Powder bed fusion'

SDGs: SDG 9 Industry, innovation, and infrastructure

SDG 12 Responsible consumption and production.

Current study year: Final year

Additive manufacturing of functional meta-crystal inspired micro-lattice materials for tissue engineering.

Suhaib Zahid

Supervisory team: Dr Arun Arjunan (Director of Studies), Dr Ahmad Baroutaji and Dr Syed Hassan

Abstract: Metallic cellular structures built upon the principle of uniform micro-lattices are the go-to within the concept of porous biomaterials for tissue engineering. However, a major drawback found within these structures is failing to achieve the correct balance between structural integrity and high porosity. Within normal lattice structures, the failure of the structure would follow the direction the crack is formed resulting in shear failure along a line in the same direction. However, within polycrystalline structures where grain boundaries are used, these boundaries would act as a type of barrier to help slow down or stop the crack that has been formed. Therefore, the aim of this research is to develop multiple meta-crystal lattices in which if a crack is created, it can be slowed down or stopped when met with a meta-crystal lattice aligned differently to its neighbours. Implementing this concept into a porous hip implant specifically the femoral stem would be beneficial as it would allow a porous implant to be produced alongside improving the mechanical properties of the implant. Literature review, 3D Modelling (CAD), Finite Element Analysis (FEA), Design of Experiments (DoE), Additive Manufacturing and Experimentation have been performed within this research to aid in reaching a solution. This study will first begin to review the problems within the tissue engineering industry more specifically regarding orthopaedic implants. It investigates current lattice structures and how they can be altered to help improve their mechanical properties. FEA was used to simulate the real-world scenarios. DoE with Design Expert has been used to output the most optimum design parameters to be then 3D printed. Experimental procedures are performed to observe the mechanical behaviour of the implant. This study allows a structure with the correct balance between structural integrity and high porosity to be used for a hip implant.

Keywords: Orthopaedic Implants, Polycrystalline Structures, Meta-Materials, Tissue Engineering, Meta-Crystal

SDGs SDG 3: Good Health and Well-being

 SDG 9: Industry, Innovation and Infrastructure

Current year of study: First year full time

Additively Manufactured Biomimetic Scaffold for Critical Size Bone Defect

Martin Appiah

Supervisory team: Dr. Arun Arjunan and Dr. Ahmad Baroutaji

Abstract Bone fractures and segmental bone defects are a significant cause of morbidity in patients and place a heavy economic burden on the healthcare system. The annual cost of treating bone defects in the United States has been estimated at \$ 5 billion, while bone grafts incur a huge cost on bone damage, tumours, and other conditions associated with poor fracture healing. A critical bone defect can occur due to severe trauma or tumours that will cause segmental bone removal. In some cases, autografts cannot fill such severe defects. Allografts can be used to reconstruct large bone defects, but these grafts may not fit into the healing response. Consequently, the reconstruction of large bone defects remains a challenge for reconstructive surgery. A variety of treatment strategies have been developed to promote the healing response and close bone defects. Suitable porosity and permeability are essential to facilitate the biological activities associated with bone growth and nutrient release. A systematic balance of all these parameters is necessary for the development of an efficient scaffold. The traditional approach has been that each of these parameters is studied in isolation, without considering their interdependence, to achieve specific properties at a given porosity. In this research, an investigation will be conducted into different design strategies that will be adopted to design of fully porous critical size bone scaffolds by bringing all parameters together at the design stage to holistically analyse the compressive, bending and shear behaviour of bone scaffolds and associated fixing mechanisms.

Keywords: Additive manufacturing; Biomimetic; Bone Scaffold; Critical Size; Titanium

SDGs SDG 3 - Ensure healthy lives and promote well-being for all at all ages

Current Year of study: Second year full time

Physicochemical and biological contaminants in drinking water and their impacts on human health

Ahsan Shah

Supervisory team: Dr Arun Arjunan, Prof Craig Williams, Dr Ahmad Baroutaji, Dr Wayne Heaselgrave

Abstract

Background The provision of clean drinking water is critical to alleviate poverty in both rural and urban regions [1]. Water is a heritage [2] and very vital natural resource that needs to be protected from pollutants [3]. Currently, only 1% of the total available water resource can be regarded as drinkable [4] due to the four type of contaminates as shown in Figure 1. Therefore, the addition of toxic chemicals in water through anthropogenic activities must be monitored and analysed [5].

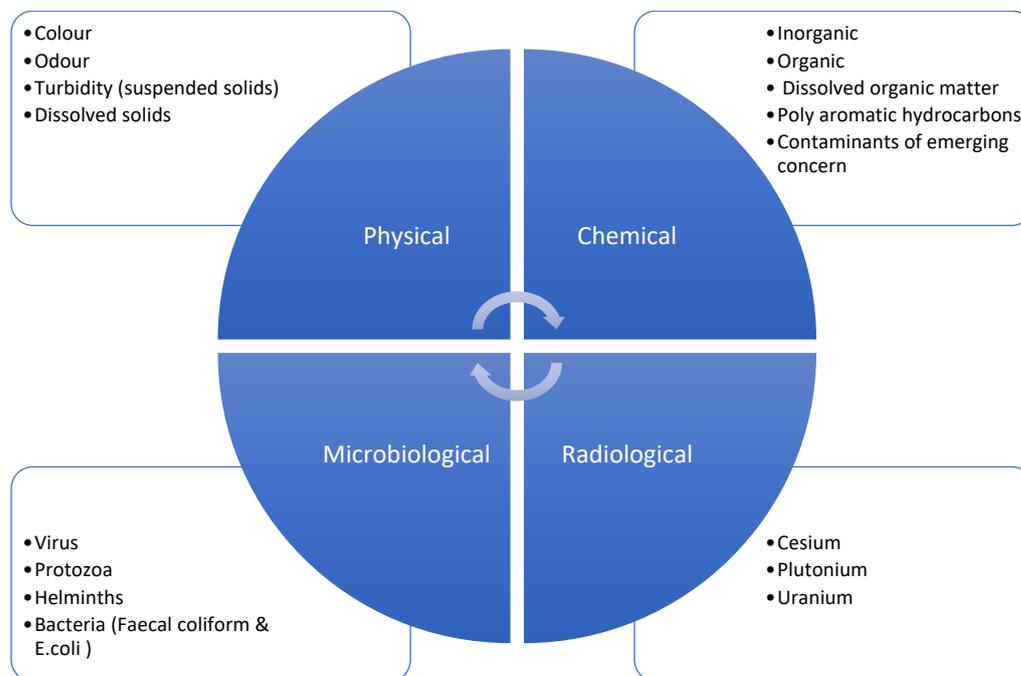


Figure 1. The four types of contaminants usually found in drinking water.

Aims The key aims of this project include (i) Identification of key contaminants in drinking water and analyse the influence of each contaminant on public health. (ii) Evaluate cost effective methods for monitoring drinking water quality (iii) Quantify the public perception of “safe drinking water” and compare it with WHO guidelines and standard parameters with a focus on public water supplies.

Method: In this study the key contaminants in drinking water were explored according to guidelines mentioned by WHO [6], which states the list of contaminants to regulate should be brief and relevant to the country and region. As the research is undertaken in the UK, the selection of contaminants is chosen from the relevant UK Drinking Water Inspectorate (dwi) reports from 2019 [7] and 2020 [8]. Subsequently, the health impacts of the selected contaminants are studied following the WHO guidance. In addition, the recommendations from EPA (USA) [9], CDC (USA) [10] and CAWST (Canada) [11] are also reviewed. Using these parameters as a reference, the prescribed limits of each contaminant were compared in both developed and the developing regions. Methods to monitor the parameters are compared with merits, demerits and limitations of each method. The Role of public water supplies is discussed by reviewing published literature.

Results: Although, the industrial advancement has drastically increased the contaminants in drinking water, there is great improvement in techniques to measuring the contaminants to exceedingly low concentrations. It was identified that the concept of “threshold limits” and “total daily intake” was most suitable for identifying contaminant limits. In developing countries, testing for pathogens is generally the most essential requirement in comparison to broad parametric testing in developed countries. Nevertheless, it is clear from the initial review that government authorities should do more regarding raising the public awareness about the water quality.

Conclusions:

1. A continuous online monitoring system is vital to keep the water parameters in control limits and meets the needs of Water Framework Directive.
2. Excessive use of treatment chemicals be avoided. Finding a source with minimum pollutants is the best solution.
3. Public water supplies in the UK are providing good quality water. However, they need improvements on maintenance, calibration of monitoring equipment and staff trainings.

Keywords: Water, contaminants, parameters, monitoring, standards.

SDGs SDG 6: Availability and sustainable management of water.

Improving the quality of drinking water is one of the priority agenda in the environmental policy and SDGs of the United Nations.

Year of Study: 1st year (Part time)

References:

- [1] WHO, Guidelines for drinking-water quality, (2017). <https://www.who.int/publications/i/item/9789241549950>.
- [2] Water Framework Directive UK, Wfd uktag, (2020). <http://www.wfduk.org/>.
- [3] Environment Agency (EA) UK, Drinking water protected areas, United Kingdom. (2019). <http://www.environment-agency.gov.uk/homeandleisure/141891.aspx>.
- [4] W. Yan, J. Li, X. Bai, Comprehensive assessment and visualized monitoring of urban drinking water quality, *Chemom. Intell. Lab. Syst.* 155 (2016) 26–35. <https://doi.org/10.1016/j.chemolab.2016.03.026>.
- [5] P.H. Gameiro, K.H. Assis, H. Hasenack, A. Arenzon, K.U. Dias Silva, C. Torres de Lemos, V.M. Ferrão Vargas, Evaluation of effect of hazardous contaminants in areas for the abstraction of drinking water, *Environ. Res.* 188 (2020). <https://doi.org/10.1016/j.envres.2020.109862>.
- [6] WHO, Household water treatment and safe storage, Treatment technologies, (2018). http://www.who.int/household_water/research/technologies_intro/en/.
- [7] Drinking Water Inspectorate (dwi), Drinking water annual report, (2019). <https://www.dwi.gov.uk/what-we-do/annual-report/drinking-water-2019/>.
- [8] Drinking Water Inspectorate (dwi), Drinking water annual report., (2020). <https://www.dwi.gov.uk/what-we-do/annual-report/drinking-water-2020/>.
- [9] United States Environmental Protection Agency (EPA), Types of Drinking Water Contaminants., (2017).
- [10] ATSDR, Substance priority list, *Subst. Prior. List.* (2020). <https://www.atsdr.cdc.gov/spl/index.html>.
- [11] CAWST, Introduction to drinking water quality testing', 2009.

Overview and recent trends of energy absorption on Thin walled structures, specifically Functionally graded thickness of 3D printed structures.

Gurpal Singh

Supervisory team: Ahmad Baroutaji and Arun Arjunan

Abstract

Background: There are many different structures to be encountered during daily life and they all serve different functions. Thin-walled structures are one such that appear in a lot of different fields, these have a very small thickness but a much larger length and width. The shape of these ranges from discs to tubes, some common examples include cans (energy drinks or soup cans). My thesis focuses on Crashworthiness of these “thin walled” structures, which evaluates how they behave during a crash. The purpose of doing such tests allows the user to look at properties related to crashing, for example the peak force that might arise in a car crash, or the energy absorbed by barriers on roads (Energy absorption) during a collision. The controlled experiments in labs for crashworthiness allow us to predict collision behaviour that happen during accidents in real-world scenarios. The purpose altogether attempts to improve the safety of humans, for example the passengers in a car, by allowing the structure of the car to absorb as much of the impact as possible. There are different factors that can affect the crashworthiness properties of structures to improve their energy absorption or the reduce the impact forces. The main factors are the shape of the structure and the material it's made from. The shape heavily impacts the way the structures fold when being crushed. The choice of material also influences the weight of the overall car and different mechanical properties, which lead to the different crashworthiness properties mentioned above.

The literature review found certain shapes have better properties than others (example circular tubes always being better than squared ones). Corrugation of the walls can lower the peak force, introducing foam fill can increase energy absorption etc. Multi cell and windowed tubes are more examples.

Aims: The aim of my research focuses on axial loading (crushing a tube top to down) and looks at an array of designs to see how they perform. A control tube (circular) is used to compare the differences. The designs are fairly simple lofts between the top cross section to the bottom (example a hexagon to an octagon) but their thickness will change according to set functions (equations) and the structure will be 3D printed.

Methodology: The current methodology uses numerical (computer) simulations on computer aided designs. The next step is to produce this structure, which will be done by a 3D metal printer, on a selected structure and then it will be compared and analysed. This will then be optimised further via a computer and techniques will be used to improve and make it as efficient as possible.

Results/Conclusion: The methodology/results are still under progress, however it is evident from literature research that functionally graded has an important part to play and shows good promise in reducing the weight but improving the crashworthiness behaviour. Additionally, the flexibility from a 3D printing method opens a whole different field to explore but can come at costs, such as being limited to material or printing dimensions.

Keywords: Crashworthiness, Thin walled structures, Functionally graded thickness, 3D printed, Varying cross sections

SDGs SDG Goal 9- Build resilient infrastructure, promote sustainable industrialization and foster innovation

Current year of study: Second year full time

Towards sui-generis of Meta-Auxeticity for osteogenic structures

Aaron Vance

Supervisory team: Dr Arun Arjunan and Dr Ahmad Baroutaji

Abstract An aging worldwide population presents a global healthcare challenge like none before. Increased prevalence of arthritic conditions will heighten the requirement for surgical intervention at many anatomic weight-bearing sites. The advent of additive manufacture (AM) technologies has established precedent for batch-size-indifference thus facilitating components with previously unattainable complexity and accuracy.

The establishment of additive manufacture techniques for load bearing biomedical application has significant potential to facilitate enhanced recovery, patient quality of life and improved cost-efficient interventions through reduced revision.

Cellular structures have the potential to transcend interdisciplinary boundaries through enhanced strength to weight ratios, such structures are defined as composites comprised of bulk solid and space. The ubiquity of cellular forms naturally occurring is testament to the mechanical efficiencies attainable of least-weight designs.

It is proposed that meta-architectures be developed that promote osseointegration of non-cemented femoral stem implants through improved bone-implant interactions.

Current research has focus on developing two and three-dimensional finite element models that accurately predict compressive performance of honeycomb and lattice structures that exhibit either Auxetic or non-Auxetic properties.

Future works seek to investigate the identified appropriate structures to attain varied and desired performance properties including relative density, strain energy and Poisson's ratio throughout the structure.

It is considered, these works will accelerate the adoption of additive manufacture technologies through the demonstration and application of Meta-architectures to load bearing structures. It is hoped this work will form the basis of future developments in this field so that personalised implants become reality.

Keywords Auxetic, Bone, Simulation, Cellular structure, Lattice, Additive manufacturing

SDGs SDG 3 - Ensure healthy lives and promote well-being for all at all ages

Current year of study: Second year part time

Additive manufacturing of antibacterial biomaterials for orthopaedic implants

Gustavo Fazalzadeha

Supervisory team: Syed Hasan, Arun Arjunan, Andrew Pollard

Abstract It is estimated that by 2030 more than 50,000 hip arthroplasty and more than 1.3 billion total knee arthroplasty will be performed each year, with the current infection rate at around ~1% to ~2% [1] [2]. To put this into perspective there will be over 26 million infections caused by orthopaedic implant surgery just on hip and knee arthroplasty. Biomaterials are used with the intention of interacting with biological systems. Biomaterials that are used as support/replacement to the skeletal system must provide mechanical properties that are compatible and integrate with bones made from cells, minerals and protein fibres (Cell liberation) all of which can only be accomplished through the use of Additive Manufacturing (AM). AM is the process in which material is added by layers and sintered using a high powered laser at each stage to form a 3D component, realised by CAD data. Biomaterials must also not cause any adverse effect on the human body such as toxicity and infections. Furthermore, biomaterials need to be designed and manufactured with an intention to stimulate Osteoinduction, Osteoconduction, Osteoinductive and Osteointegration. For these reasons, they are heavily regulated to include bio-compatibility, bio-functionality, and bio-adhesion to name a few [3] [4]. Medical surgeries undertake the highest level of aseptic surgical practices to help fight, protect and prevent infections [5]. Even with the most stringent protocols, infections are only mitigated to a certain degree due to bacteria fighting back. Good practices and antibiotics help to a high degree on the surface but deep bacterial infections have the ability to bind to the surface of biomaterials due to their physical and chemical properties. Bacterial adhesion on biomaterial surfaces during surgery is known to be a preferential site for bacterial colonization such as *E. coli*, especially at a time when the immune system is vulnerable [6]. Nosocomial infections (infections that are contracted from certain locations for instance hospitals) *Staphylococcus aureus* (*S. aureus*) and *Staphylococcus epidermidis* (*S. epi.*) are associated with biofilm [7]. The build-up of biofilm post-surgery is a strategically systematic attack in preventing phagocytosis release, by evading phagocyte and lymphocyte white blood cells [8]. Bacteria such as *Escherichia coli* have mutated to adhere and invade their host cells [9]. This study aims to manufacture optimum antibacterial biomechanical bone scaffold to counteract deep

bacterial infection during and after orthopaedic surgery and prevent the build-up of biofilm. The use of process parameters and powder characterisation of metal powders will be used to develop multi-layer single layer tracks, walls, cubes to be tested using SEM, XRD and Ct scan. Mechanical and microstructural characterisation of newly derived material composition for experimental testing and validation of the optimum biomechanical bone scaffold.

Keywords: Biofilm, Bacterial adhesion, biomaterials, Additive Manufacturing, Osteointegration, Cytotoxicity

SDGs SDG 3: Good Health and Well-being

 SDG 9: Industry, Innovation and Infrastructure

Current year of study: Second year full time

3D Printed redistributed manufacturing of anti-SARS-CoV-2 Copper-Tungsten-Silver

John Robinson

Supervisor team: Dr Arun Arjunan and Dr Ahmad Baroutaji

Project collaborators John Robinson, Arun Arjunan, Ahmad Baroutaji, Miguel Martí, Alberto Tuñón-Molina, Ángel Serrano-Aroca, and Andrew Pollard

Abstract March 11th, 2020 saw the World Health Organisation (WHO) declare a global pandemic following the COVID-19 outbreak. The contagious disease caused by the Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) is transmitted through respiratory droplets or contaminated surfaces resulting in fatal respiratory infections. Therefore, reducing airborne and surface-based transmission of the virus is essential where antiviral materials and surfaces offer much potential. Additionally, the pandemic has emphasised global supply chain and manufacturing limitations causing shortages of essential COVID-19 related supplies including Personal Protective Equipment (PPE), nasopharyngeal swabs, and ventilators. Consequently, combining digital manufacturing techniques with anti-SARS-CoV-2 materials has the potential to alleviate traditional transportation and supply chain limitations allowing close to end user and point-of-care manufacture.

Accordingly, this research demonstrates the use of Selective Laser Melting (SLM) Additive Manufacturing (AM) (also known as 3D printing) to fabricate a novel antiviral copper-tungsten-silver (Cu-W-Ag) material and microporous geometry with superior anti-SARS-CoV-2 properties. Additionally, the 3D printed Cu-W-Ag material and microporous structures are shown to be suitable for redistributed manufacturing as the geometry is not informed by complex Computer Aided Design (CAD) data. Instead, the pore morphology is derived through a multi-objective surrogate model that carefully manipulates the SLM process parameters. This methodology simplifies the 3D printing process where only the global dimensions of the targeted geometries are required allowing unhindered file transfer while simplifying CAD input. The surrogate model predicted an optimum parametric combination, which resulted in microporous Cu-W-Ag with average pore sizes of 80 μm . Subsequent antiviral evaluation of the optimum architecture displayed 100% viral inactivation within 5 hours against a biosafe enveloped RNA viral model of SARS-CoV-2. As such the Cu-W-Ag material developed in this study can be utilised to reduce both surface contamination and the airborne

spread of SARS-CoV-2. Furthermore, a potential proof of concept application is demonstrated utilising the antiviral Cu-W-Ag material and 3D printing methodology to fabricate anti-SARS-CoV-2 mask filters mimicking an open-source design.

As the pandemic evolves, various situations are likely to appear unpredictably where carefully conceived 3D printable antiviral materials ready for redistributed manufacturing can achieve immediate response for rapid solutions. In this regard, this research is the first open and collaborative approach in the digitalised manufacture of an anti-SARS-CoV-2 material. While the methodology reported informs prototype face mask filter geometries, the approach can be adopted for developing complex Heating, Ventilation, and Air Conditioning (HVAC) antiviral filtration systems for both the general community and health care settings alike.

Keywords: Digital manufacturing; SARS-CoV-2; COVID-19; copper-tungsten-silver; antiviral.

SDGs SDG 9 Industry innovation and infrastructure.

 SDG 12 Responsible consumption and production

 SDG 1 No poverty

 SDG 11 Sustainable cities and communities

 SDG 13 Climate Action

The multidisciplinary approach proposed in this research includes antiviral materials, predictive modelling, redistributed digital manufacturing, and an anti-SARS-CoV-2 application. Therefore, this research aligns strongly with United Nations Sustainable Development Goals (SDG's) 9 and 12 with links to 1, 11, and 13.

SDG 9 – Industry innovation and infrastructure.

Tariffs and trade tensions has seen manufacturing declining while investment in R&D activities needs to increase. The development of antiviral materials and redistributed manufacturing techniques could aid in increasing R&D investment while redistributed digital manufacturing techniques could help increase manufacturing growth.

SDG 12 – Responsible consumption and production

Rising fossil fuel subsidies are contributing to climate change. Redistributed manufacturing offers the potential to reduce transportation and supply chain pollution, reducing reliance on fossil fuel usage by delivering digital manufacturing direct to the end user.

SDG 1 – No poverty

COVID-19 has caused the first increase in global poverty in decades with +71 million people pushed into extreme poverty in 2020. The development of antiviral materials

and surfaces along with redistributing manufacturing at point of care has the potential to aid the reduction in virus transmission.

SDG 11 – Sustainable cities and communities

Over 90% of COVID-19 cases are in urban areas. Antiviral materials and surfaces deployed on touch points for public transport and in urban areas has the potential to reduce virus transmission.

SDG 13 – Climate Action

Climate change natural disasters effected 39 million people in 2018 however investment in fossil fuels continues to be higher than in climate activities. The redistribution of manufacturing could aid the reduction of global fossil fuel consumption.

Current year of study: Fourth year part time

Quality Assurance of Metal Additive Manufacturing Processes for Aerospace Applications

Neil Basini

Supervisory team: Arun Arjunan

Abstract

Background: Additive Manufacturing (AM) processes are currently being developed and adopted in a range of industries, including the aerospace industry. Quality assurance is a crucial aspect of these developments for aerospace, as flight-critical parts must be free from defects.

Aims: The primary aim for this research is to provide further confidence in additive layer manufacturing as a mature and robust technology, in terms of equipment, methods and standards.

Method(s): The research consists of monitoring and characterising the additive manufacturing build process to understand how the part quality is affected. This investigation covers the machine limitations, process variability, build process parameters, their interdependencies, the characterisation of the melt pool, the resultant material quality, and the associated quality defects.

The whole process is considered, which involves reviewing the machine setup, in-process monitoring equipment, post-build processing of parts, part inspection methods (e.g. CT scanning), and relevant industry standards for suitability in detecting and mitigating against the defects that are associated with AM parts.

Melt pool monitoring equipment is being assessed as a potential quality assurance method for monitoring parts for defects.

Results: Preliminary tests have been completed on the quality of parts and compared to melt pool monitoring data, to review the latter's suitability at finding defects. Results suggest that while melt pool monitoring is able to detect certain defects, it appears to be an immature technology as the long processing times make it difficult to analyse whether an in-progress build is building correctly. Higher resolution, faster processing speeds, and new software features are required before this specific technology can provide the level of confidence needed to aid inspection and quality assurance.

Collaboration and dissemination activities in the industry are more frequent and widespread, but a lot of developments are still hidden behind non-disclosure agreements and industry standards are a work in progress.

Conclusions: This work is helping to provide confidence in the use of AM methods in aerospace applications, by demonstrating that quality assurance processes are suitable for finding the associated defects.

Keywords: additive manufacturing, aerospace, in-situ monitoring.

SDGs SDG 9 Industry innovation and infrastructure

The work aligns with Sustainable Development Goal 9, as it will help the aviation industry to continue innovating in the field of new manufacturing technology development, with an emphasis on flight safety. Detailed in-process monitoring and robust quality assurance processes will also help manufacturers achieve right-first-time production, in turn reducing material waste and limiting energy consumption.

Current study year of study: Fourth year part-time

Mechanical performance of Additively manufactured Aluminium Auxetic Structures

Manpreet Singh

Supervisory team: Dr Arun Arjunan, Dr Ahmad Baroutaji

Abstract Additive manufacturing (AM) is gradually being recognized for its potential to support sustainable design. In this regard, the potential of AM to produce metallic structures that can exhibit auxetic behaviour is of significant interest. The auxetic behaviour is non-traditional and allows for superior mechanical and energy absorption capabilities, so the potential application of using Auxetic structure in Electric vehicle battery will be explored in this research. The focus will be primarily on the influence of design parameters such as thickness (t) and auxetic angle (θ) on mechanical performance of additively manufactured auxetic lattices. AM is revolutionary in this aspect: there are two fundamental aspects that define sustainable manufacturing: the actual manufacturing process and the impact of the product produced. Even though AM has significant effects at both levels; the research is focused on the second aspect which is the impact of complex parts produced. Following the critical review of literature, the research aims to design and study the mechanical performance of Auxetic structures. The output of this research will aid in the development of lightweight auxetic structures for various energy absorption application such as protective casing for electric vehicle battery.

Keywords: Additive manufacturing; Auxetic Structures; Aluminium; Hierarchical design; Mechanical performance

SDGs SDG 9
 SDG 12
 SDG 13

The current research project contributes towards achieving the United Nation's Sustainable Development Goals (SDG) 9, 12 and 13.

Current year of study: Third year full time

Adoption of selective laser melting for the development of Cobalt-Chromium-Molybdenum functional auxetic bone scaffold

Chameekara Tharumal Wanniarachchi

Supervisory team: Dr Arun Arjunan, Dr Ahmad Baroutaji

Abstract Auxetic structures are unusual architectures that show unconventional strain behaviour resulting in negative Poisson's ratio. In doing so, these structures exhibit deformation modes and mechanical characteristics that are different from traditional porous architecture. This can lead to favourable outcomes for load bearing tissue engineering applications; which, this research is aiming to exploit. As a first step, this paper presents an overview of the latest advances in the area of metal additive manufacturing and auxetic tissue engineering. Primary attention has been on identifying the trends in biomedical auxetic structures along with their mechanical performance. Following the critical review of literature, Cobalt-chromium-molybdenum (CoCrMo) has been chosen as the biomaterial of choice as a result of its high elastic modulus (210-250GPa) and density (8.4 gcm⁻³) leading to superior stiffness performance. This in turn allow for significant opportunity to develop porous auxetic structures that can reduce stress-shielding effects associated with highly stiff implants. With this aim, the research investigates the suitability of CoCrMo porous auxetic designs that allows for functional bone scaffold featuring the mechanical properties of the host bone. The literature review found that auxetic structures show unique properties in comparison to conventional porous structures in elastic strain, indentation resistance, shear modulus and fracture toughness. This can subsequently help develop functional CoCrMo auxetic bone scaffolds to mimic the mechanical behaviour of the host bone while reducing stress-shielding and maladaptation. Auxetic structures has been designed and manufactured by using Direct metal laser sintering process and the experimental data was compared with finite element analysis data. In doing so, this research adds to the state-of-the-art in patient-specific implant design thus accelerating post-surgery recovery.

Keywords: Auxetic structures, Negative poison's ratio, Additive Manufacturing, Biomaterials, Design and modelling

SDGs SDG 3

 SDG 9

Current year of study: Second year full time

Study of Battery Modelling techniques for optimal performance of Lithium-ion battery technology in residential and mini-smart grid applications.

Folarin Emmanuel Ojetoro

Supervisory team: Professor Nduka Nnamdi Ekere, Dr Fideline Tchuenbou-Magaia and Dr. David Adebayo

Abstract As part of the United Nations Sustainable Development Goals with particular focus on goal 9, which is: Build Resilient Infrastructure, Promote Sustainable Industrialisation and Foster Innovation, increasing research efforts are being intensified on clean energy and particularly electrochemical energy storage. This is consistent with the fact that though a lot has been discovered in the past few decades, it is an area which still offers more possibilities, innovation and increasing efficiency. Of these electrochemical storage devices, the lithium-ion battery stands out due to features which makes it favourable for consumer products, automotive and grid applications. It is well known fact that the technology consists of different chemistries. These chemistries include different cathode materials like Lithium Cobalt Oxide (LiCoO_2), Lithium Manganese Oxide (LiMn_2O_4), Lithium Iron Phosphate (LiFePO_4), Lithium Nickel Manganese Cobalt Oxide (LiNiMnCoO_2), Lithium Nickel Cobalt Aluminium Oxide (LiNiCoAlO_2), and Lithium Titanate (LTO). As a result of the different features of these lithium-ion batteries, one may be more suited to the others depending on the required application and the battery model. Battery modelling is a very good approach to determine the optimal properties of the battery which includes charge and discharge characteristic curves, state of charge and lifetime of the battery. For analysis and prediction of the states and other important features of the lithium-ion batteries, several types of modelling are suggested in literature. The type of modelling employed often depends on the application and its accuracy demands. The common types of modelling include: Electrochemical model, Analytical model, Stochastic model, Equivalent circuit model etc. The electrochemical modelling approach involves the establishment of links between concentration of active materials in an element (microscopic data) and macroscopic data such as voltage or temperature of the battery system. As a result of the vast amount of variables involved in this model, the cost of computerisation is vastly high, and the use is mostly limited to laboratory applications and not real-life use. The equivalent circuit model on the other hand is mostly used as it gives distinct representation of the electrical properties of the battery system. It thus

offers less computational cost although less detail of the internal and dynamic properties of the battery.

Knowledge of the types of lithium-ion models for the different applications is very crucial to maximising the enormous potentials of the technology. This work will look to review existing literatures on the types of battery modelling with a view to highlighting the features and applications of the modelling types. Efforts will also be made to identify knowledge gaps for the purpose of further research work on the different modelling types.

Keywords Lithium-ion batteries, electrochemical model, energy storage, state of charge, equivalent circuit modelling.

SDGs SDG 9 Build Resilient Infrastructure, Promote Sustainable Industrialisation and Foster Innovation.

Current year of study: Second year full time

5G Network: Expectation vs Reality

Mobolanle Bello

Supervisory team: Prof. Pillai Prashant and Dr. Sadiq Ali

Abstract The promise of 5G network has been lauded for a long time, but it is now finally becoming a reality. 5G was finally introduced into the market after years of creating buzz about the lightning-fast speeds offered by the latest generation of mobile network technology; and this was followed by massive rollout and deployment in 2020. The introduction of 5G is going to transform the way we connect in 2021 and beyond. It will influence the use of internet of things (IoT), mobile devices and sensor technologies in critical industries including smart cities, automotive, industrial, communication, wearables and consumer electronics. 5G is set to usher in a new phase of better and more effective connection and service.

Though the arrival of 5G technology and its futuristic future applications has been received with great excitements and high hopes, it is important to note that the 5G implementation is still in its infant stage. Therefore, it is believed that the current hype surrounding its transformational impact is premature as there is far more work that needs to be done before networks can start delivering upon the upper echelons of what 5G has promised.

This paper examines the possible future applications of 5G network, where the technology is today, its implementation issues, and what the industry is doing about it.

Keywords: 5G Network, Mobile Network Technology, Wireless Communication, Internet of Things

SDGs SDG 9 Build Resilient Infrastructure, Promote Sustainable Industrialisation and Foster Innovation.

Current year of study: Third year full time

A Flow-based Multi-Agent Data Exfiltration Detection Architecture for Ultra-Low Latency Networks

Rafael Salema Marques

Supervisory team: Prof Dr Haider Al-Khateeb

Project collaborators: Gregory Epiphaniou, Warwick Manufacturing Group (WMG), University of Warwick, Haider Al-Khateeb, University of Wolverhampton, Carsten Maple, Warwick Manufacturing Group (WMG), University of Warwick, Mohammad Hammoudeh, Department of Computing and Mathematics, Manchester Metropolitan University, Paulo Andre Lima De Castro, Autonomous Computational Systems Lab, Aeronautics Institute of Technology (ITA), Brazil, Ali Dehghantanha, Security of Advanced Systems Lab, School of Computer Science, University of Guelph, Canada, Kim-Kwang Raymond Choo, Department of Information Systems and Cyber Security, University of Texas at San Antonio, USA

Abstract Modern network infrastructures host converged applications that demand rapid elasticity of services, increased security and ultra-fast reaction times. The Tactile Internet promises to facilitate the delivery of these services while enabling new economies of scale for high-fidelity of machine-to-machine and human-to-machine interactions. Unavoidably, critical mission systems served by the Tactile Internet manifest high-demands not only for high speed and reliable communications but equally, the ability to rapidly identify and mitigate threats and vulnerabilities. However, it is paramount to build a resilient infrastructure to support economic development and survive to adversaries attacks. This paper proposes a novel Multi-Agent Data Exfiltration Detector Architecture (MADEX) inspired by the mechanisms and features present in the human immune system. MADEX seeks to identify data exfiltration activities performed by evasive and stealthy malware that hides malicious traffic from an infected host in low-latency networks. Our approach uses cross-network traffic information collected by agents to effectively identify unknown illicit connections by an operating system subverted. MADEX does not require prior knowledge of the characteristics or behaviour of the malicious code or a dedicated access to a knowledge repository. We tested the performance of MADEX in terms of its capacity to handle real-time data and the sensitivity of our algorithm's classification when exposed to malicious traffic. Experimental evaluation results show that MADEX achieved 99.97% sensitivity, 98.78% accuracy and an error rate of 1.21% when compared to its best rivals. We created a second version of MADEX, called MADEX level 2 that further improves its overall performance with a slight increase in

computational complexity. We argue for the suitability of MADEX level 1 in non-critical environments, while MADEX level 2 can be used to avoid data exfiltration in critical mission systems. To the best of our knowledge, this is the first article in the literature that addresses the detection of rootkits real-time in an agnostic way using an artificial immune system approach while it satisfies strict latency requirements.

Keywords: Artificial Immune Systems, Multi-Agent Systems, Flow-based Analysis, Rootkits, Tactile Internet

SDGs SDG 9 Protection of Industry, innovation and infrastructure

Current year of study: Second year full time

Developing a conceptual model by using a new tool to improve the E-learning systems usage during the Covid-19 pandemic in Libyan universities

Marwa Alghodi

Abstract

Background This study will find out the main factors that use to a successful e-learning system and identify the critical challenges that may be influenced on adopting the best e-learning system (VLEs) by adding a tool that will overcome the challenges and concerns during the covid-19 pandemic in Libyan universities.

Research Aims The research will develop and validate a model that contains the main factors to overcome the challenges and concerns for an effective implementation of an e-learning system in Libya.

Methods This research adopted a mixed-methods methodology that incorporates quantitative and qualitative methods for data collection. This research combines explanatory and exploratory approaches to achieve the objectives.

Conclusion This pandemic has imposed e-learning systems that mean in this study the Virtual Learning Environments (VLEs) to become the only way to continuing the education process in universities, which made many universities, particularly in the developing countries, face this challenge, considering that this situation has never happened before, accordingly, new challenges and factors will emerge, which have to be fully clarified and studied.

Keywords Libya, VLEs, Covid-19, High Education

SDGs SDG 4 Quality education

 SDG 5 Gender equality

Using Scents to Improve the Welfare and Breeding of Zoo Lemurs

Emily Elwell

Supervisory team: Dr Stefano Vaglio, Dr Chris Young, Dr Stefano Kaburu

Abstract Zoos around the world play an important role in housing and contributing to the conservation of endangered lemurs through breeding and reintroduction programmes. However, the mismatch between the zoo and wild environment can cause problems of stress and boredom which can in turn impact on the success of breeding. Lemurs communicate extensively via scents, including for reproduction, but less attention has been received in regards to using sensory enrichment in zoos to improve lemur welfare and how this in turn might impact on breeding programmes. This project aims to investigate the effects of a new scent enrichment programme on captive lemurs to both improve welfare and encourage breeding. Initial work has been completed with both crowned lemurs and red-ruffed lemurs. Scents from the lemurs were collected for lab analysis and the behaviour of individuals was observed to understand their scent-marking behaviours. Scents from red-ruffed lemurs were collected during their fertile and non-fertile period. Key compounds identified from female fertile scents will be used to develop a novel scent enrichment to test its effects on both welfare and breeding behaviours. Significant differences were found between males and females in relation to their scent-marking behaviours and both species displayed frequent investigation via sniffing. This project will provide zoos with a new way to enrich lemurs to both improve their and potentially improve reproductive success which will have a positive effect on conservation of endangered species.

Keywords: conservation breeding, scents, enrichment, animal welfare, primates.

SDGs SDG 15 – Life on land

Current year of study: Second year full-time

Evaluation of the antimicrobial activity of *Trachyspermum ammi* (Ajwain) seeds and *Plectranthus amboinicus* (Indian borage) leaf extracts on planktonic forms and biofilms of *Staphylococcus aureus* and *Pseudomonas aeruginosa*

Sheeba. S. Sawant

Supervisory team: Dr. Ayesha Rahman, Dr. Timothy Baldwin, Dr. Habib Khan,

Abstract

Background: The burden of biofilm associated diseases has challenged the drug development progress. This has led to emergence of multidrug resistant bacteria. In pursuit to find a solution to this problem, the presence of antimicrobial compounds in *Plectranthus amboinicus* leaves and *T. ammi* seeds (AA1, AA2 and AA93 genotypes) were investigated. These medicinal plants can be a source of new therapeutic drugs and anti-biofilm agents. This study allows us to explore the potential of these multi-functional herbs for several biomedical applications.

Methods: Cryo- SEM and freeze fracture technique were used to study the native-hydrated state of cell membranes, glandular trichome and its distribution on *P. amboinicus* leaves. Active constituents were observed in solvent extracts of *T. ammi* seeds and *P. amboinicus* leaves using agar cup diffusion assay. Development of *S. aureus* and *P. aeruginosa* biofilm was performed using crystal violet assay with some modifications adapted from O'Toole (2011). Reduction in biofilm density and anti-biofilm inhibitory activity due to antimicrobial properties produced by the extracts was quantified using biofilm dispersal and inhibition assays, respectively.

Results: The growth curve of *Plectranthus amboinicus* illustrated four developmental stages, lag, initial exponential phase (log) and exponential phase, and stationary phase. Cryo-SEM images displayed maturation of glandular trichome and conical root hair and its distribution on *P. amboinicus* leaves. The glandular trichomes are explored to secrete the active constituents and conical root hair protects the plant from predators and dehydration. Freeze fracture images showed different mesophyll layers, epidermis, and their cellular structures, giving us a clearer view of leaf morphology. Acetone was observed to be the most efficient solvent in extracting the antimicrobial compounds from *T. ammi* seeds and *P. amboinicus* leaves. Acetone extracts of AA1 showed antibacterial activity against *E. coli*, *S. aureus*, *P. aeruginosa* and *B. cereus*. In biofilm dispersal assays of *S. aureus* biofilm, AA1 (79.4%) revealed maximum reduction followed by AA2 (58.1%) and AA93 (51.3%), however, *P. amboinicus* (IB)

extract showed decent antibiofilm activity with 78.6% reduction. With *P. aeruginosa* biofilm, AA2 extract (62.8%) showed the highest reduction followed by AA1 (45%) and AA93 (20%) extracts. IB extract (34.05%) showed moderate reduction in the biofilm density.

In inhibition assay, AA1 caused the lowest inhibitory effect of biofilm in *S. aureus* (60%) and 60% in *P. aeruginosa*. The highest antibiofilm inhibitory activity was observed against *S. aureus* (91%) and *P. aeruginosa* (88.5%) caused by the Indian borage extract. AA2 extracts inhibition percentage ranged from 63% to 68.5% in both the organisms, respectively. AA93 extracts (80%) showed significant inhibitory effect as compared to the other *T. ammi* seeds genotypes against *S. aureus* and *P. aeruginosa*. In summary, the results were more prominent against Gram-positive bacteria than Gram-negative bacteria.

Conclusion: The antibacterial and anti-biofilm effect of *T. ammi* seeds and *P. amboinicus* leaves proves to be a promising alternative against bacterial biofilm and source of antimicrobials drugs.

Keywords: biofilm, MDR, medicinal plants, biomedical, anti-biofilm

SDGs SDG 3: Good health and well-being

Current year of study: Second year full-time

An Investigative Study of Micro-organisms associated with Heritage Buildings

John Peter Cooney,

Supervisory team: David Oloke, Louis Gyoh.

Abstract

Background Owing to the role that micro-organisms play in old buildings, it can be seen that the need to comprehend the composition and functionality of complex microbial groups, within ancient structures is important as to ascertain if it is dangerous to health. This research aims to demonstrate the possibility of showing this within a process of demolition and refurbishment on a heritage building information modelling platform.

Purpose little or no application exists regarding the implication or recording of health and safety information, (especially legislation), primarily aimed at ancient structures, and specifically at designated areas of demolition and refurbishment, particularly considering the inclusion of the identification of micro-organisms, which have adapted to varying environmental conditions throughout time.

Aims The production of a prototype Exchange Information Requirement (EIR) for Heritage BIM-enabled projects, to show a working BIM/HBIM (Historic Building Information Modelling) model to identify micro-organisms found within an ancient monument or otherwise; to produce a full analysis within a platform that informs the stakeholder of the micro-organism communities present; its analysis; to highlight results and portray a document management system within a BIM/HBIM platform to give guidance to what health & safety legislation may be required or sought, within the refurbishment industry.

Method Initial collection of specimens from site will be analysed using a Nano drop sequencing method, then to enhance utilising PCR, (Polymerase Chain Reaction), to extract DNA, to determine within the micro-organism Kingdom, the community it belongs to and its effect within a working environment. All results will be portrayed within the HBIM model and relayed to a data management system as to give guidance for health and safety legislation required regarding refurbishment within this monument or similar.

Results Data collection and samples taken from site have proved positive, as regards micro-organisms being present within the structure. It was found that within the Phylum level, Cyanobacteria, has considerable prevalence, which confirms the research

hypothesis. Many other species were detected from the sample analysis at that taxonomic level, however this will also be seen as a significant factor within the research. This would have a significant impetus within construction, heritage and the refurbishment of old and ancient monuments.

Conclusion The results obtained from the PCR DNA extraction, will create a standardisation and availability for such information from ancient monuments. By making available all data stored on a suitable BIM/HBIM medium, it will enable a safe interface to on-site refurbishment and demolition work within the appropriate health and safety guidelines and legislation.

Keywords DNA, HBIM, Micro-organism, Polymerase Chain Reaction, Refurbishment.

SDGs SDG 9 Protection of Industry, innovation and infrastructure

Current year of study: Third year

A novel method to inform the selection of urban dark corridors for bats

Morgan Hughes

Supervisory team: Dr Christopher H Young; Dr Simon T Maddock

Abstract Globally, 27% of animal species are listed as threatened, near-threatened or data deficient by the IUCN. For bats, that number is over 40%, and here in the UK it is 53%, with 9 of the UK's 17 species red-listed as of 2020. In the post-COVID era, the public perception of bats has deteriorated, and the need for conservation of species is ever more urgent, particularly in urban areas where humans share their landscape with wild bat species.

While bats and their roosts are afforded protection by UK and European legislation, no statute exists to preserve their vital foraging grounds, swarming sites or commuting routes. One of the most effective ways to achieve favorable conservation status for bats in cities is the preservation of commuting routes to enable bat dispersal for feeding and mating. While some urban planning authorities have implemented the designation of 'dark corridors' for bats in order to facilitate this movement, this is often done without the substantial data required on the existing flight routes of bats to inform the selection of appropriate candidate areas to set aside.

This study presents an inexpensive, robust and repeatable method for determining which urban waterways are key for bats, for identifying commuting routes and for quantifying commuting traffic along those routes. It focuses on Daubenton's bat (*Myotis daubentonii*) and its movements along the canal network within Birmingham and the Black Country.

Preliminary data have indicated the importance of 'blue bridges' in at least two sites in the study area (where bats are using viaducts to cross extensive open areas and motorway junctions) as well as vital points at which bats are crossing railway infrastructure. This has led to the subsequent identification of key foraging areas on a landscape scale.

The results of this work can inform local planning authorities and the NGOs with whom they work towards biodiversity targets to select dark corridor routes based on an informed dataset. This will allow for the preservation of existing commuting routes and will facilitate the safe crossing of hardstanding and urban infrastructure for a group of endangered species against which the cards are currently firmly stacked.

Keywords: urban planning; sustainable cities; biodiversity loss; endangered species

SDGs SDG 11 Sustainable Cities

 SDG 15 Life on land

Current year of study: Third year part time

γ -poly(glutamic acid): a Bacterial Exopolymer at the Epicentre of an Integrated Biorefinery Concept

Mattia Parati

Supervisory team: Prof. Iza Radecka, Dr. Fideline Tchuenbou-Magaia, Dr. Ibrahim Khalil

Abstract The current need of sustainably produced biodegradable polymers, is driving the demand for chemically and biologically synthesised 'green polymers'. The purpose of this work is to harness microorganismal biochemical pathways for the conversion of organic waste material into property-specific biomaterials; such as biodegradable γ -poly(glutamic acid) and poly(hydroxyalkanoates) to replace conventional plastics (or plastic derived) products. The biosynthesis of γ -poly(glutamic acid) and poly(hydroxyalkanoates) is achieved through small scale/pilot fermentations (shake flask, 1L and 5L fermentations) over a 48 - 72 hour period for optimal yield. Material characterisation is achieved through advanced, chemical analytical techniques. Our group has previously shown that γ -poly(glutamic acid) synthesised by *Bacillus subtilis* natto has been suitable for the protection of probiotics through the human digestive system, that high molecular weight γ -poly(glutamic acid) is capable of sequestering heavy metals in wastewaters and that high D-glutamic acid ratio γ -poly(glutamic acid) can shield viruses from being recognised by the human immune system. With this work, recent advancements in substrate optimisation, microorganismal genetics and fermentation techniques have been collated to aid the development of an integrated biorefinery concept. The objective has been to tackle cost, flexibility and circular economy issues faced by the 'green dreaming' polymer industry.

Keywords: Biodegradable polymers, biomaterials, sustainable economy, circular economy, microbial biotechnology

SDGs SDG 12 Responsible consumption and production

Current year of study: First year full time

Development of Efficient Workflows for Bioprocessing the Human Skeletal Myoblast Secretome

Amani Rageh

Supervisory team: Bernice Wright (PI) and Sharada Kilari

Abstract

Background The application of cell secretomes, i.e. soluble proteins, exosomes, and microvesicles secreted by cells, are major developing business models for a number of biopharmaceutical companies (e.g. Astra Zeneca, Codiak Biosciences, ReNeuron). Skeletal myoblast secretomes have shown great potential to become part of emergent clinical and commercial markets for cell-derived biotherapeutics. The whole skeletal myoblast secretome markedly reduces inflammation of cartilage, regulates cartilage matrix production and improves the health of bone. Those developments into cell secretome research have led to a demand for commercially viable bioprocesses for industrial scale manufacture of processed secretome products.

Aims The key aim of the current research programme is to scale up manufacture of human skeletal myoblast secretomes using efficient bioprocess workflows.

Methods(s) Human skeletal myoblasts were seeded at densities of 1×10^5 and 2×10^5 in 3 mL differentiation medium on a 25cm² surface area (T25 flask) and cultured over a period of 5 days to achieve 80% confluency. Separate cultures of human skeletal myoblasts were prepared using 1×10^5 cells seeded in either 3mL or 5mL of differentiation medium. Those cell cultures were maintained over a 5-day period until cells achieved 50% confluency. The myogenic secretomes were harvested, centrifuged at 1000 rcf for 5 min to remove cell debris. Microvesicle and soluble protein fractions were isolated using size exclusion chromatography (qEVoriginal izon column) and concentrated using amicon filters. The bicinchoninic acid assay was used to measure the concentration of protein in the whole secretome and isolated microvesicle and protein fractions.

Results showed that increasing the volume of differentiation medium and the skeletal myoblast density enhanced the yield of secreted myogenic proteins and microvesicle proteins. The amount of soluble protein (3mL – 76.1 µg/mL; 5mL – 163.9 µg/mL) and microvesicle (3mL – 38.3 µg/mL; 5mL – 122.8 µg/mL) protein from cells cultured in 5 mL differentiation medium was 2-fold and 3-fold greater respectively than that from cells cultured in 3mL differentiation medium, over a 5-day period. Cells that were 80%

confluent (577.5 µg/mL total protein) on a 25cm² surface area (T25 flask) generated 47% more soluble protein and microvesicle protein in the whole cleared (cell debris removed) secretome than those that were 50% confluent (306.1 µg/mL total protein) on a 25cm² surface area.

Conclusion Taken together, the results indicated that culture conditions used in the present study for generating a myogenic secretome require significant scaling up of medium volume and cell numbers to produce greater yields of secreted microvesicles and proteins.

Keywords Myogenic secretome, secretome bioprocessing workflow, secretome yield

SDGs SDG 3 – Good health and wellbeing

Current year of study: First year full time

A synthetic approach to functionalised Dithienylethenes and their future application as photo-switchable building blocks for photoresponsive supramolecular polymers.

Dr Nikolay S. Kondratyev

Supervisory team: Dr Daniel J. Keddie

Abstract

Background Dithienylethenes (DTEs) are widely known as molecular photoswitches with several inspiring fields for possible applications as highly advanced materials, which properties may be altered by irradiation with visible and UV light¹ (Scheme 1). On the other hand, while photoresponsive hydrogen-bonding molecular networks (Scheme 1) are a hot topic in Supramolecular Science and drug delivery², the potential of DTEs ($1 \rightleftharpoons 2$) for their use in such materials is underestimated³ with only a few precedents available in the literature.⁴

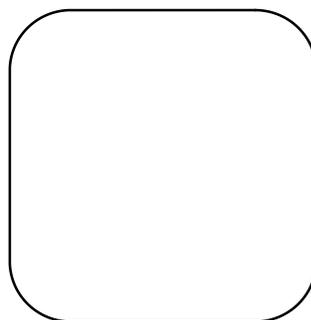
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Scheme 1

Aims Moved by this observation, we have decided to develop a general and efficient synthetic approach towards the various functionalised DTE Molecular Switches (6a and 6b, Scheme 2) to use them in future as building blocks in the preparation of the photoswitchable polymeric materials for drug delivery and other possible medicinal applications.



Scheme 2

Methods Starting with 5-methyl-2-acetylthiophene and 5-methyl-2-thiophenecarbaldehyde we have initially synthesised and studied the Ir-catalysed C-H borylation reaction of disubstituted hindered 5-methyl-2-(1,3-dioxolanyl)-thiophenes **3a** and **3b** (Scheme 2). The corresponding borylated products **4a** and **4b** were expected to be used in Suzuki-Miyaura coupling reaction to yield the corresponding DTE molecular switches **6a** and **6b**.

Results Initially, we attempted to perform Ir-catalysed borylation of both acetals **3a** and **3b**, and it was found that while borylation of **3a** gives exclusively 4-borylation product with a full conversion and 63% multigram-scale yield, the borylation of **3b** in the same conditions proceeds much slower and with only 40-50% conversion even at 100 mg scale, and gives 1.3-1.4:1 ratio of 3-/4-borylation (with an unwanted regioisomer as major). To tackle this issue, we have performed the bromination of 5-

methyl-2-thiopenecarbaldehyde with 100% regioselectivity and 90% yield, to recover 4-bromo-5-methyl-2-thiophenecarbaldehyde which will be chemoselectively converted into **4b** using Miyaura Pd-catalysed debromoborylation reaction (Scheme 2, **4b** to **6b**).

Conclusion In conclusion, we have demonstrated a powerful approach towards functionalised DTEs bearing both enolisable and non-enolisable carbonyl groups for the future synthesis of a wide range of molecular switches for their incorporation into advanced photoresponsive materials.

Keywords: Medicinal Photoresponsive Polymers; Self-Healable Organogels, Ocular Drug Delivery, Advanced Materials; Self-Regenerating Composites

SDG: SDG 3 Good health and wellbeing

SDG 9 Protection of Industry, innovation and infrastructure

References:

- 1 T. Fukaminato, S. Ishida and R. Métivier, *NPG Asia materials*, 2018, **10**, 859-881.
- 2 K. M. Hutchins, *Royal Society Open Science*, 2018, **5**, 180564.
- 3 L. Wei, S. Han, T. Jin, T. Zhan, L. Liu, J. Cui and K. Zhang, *Towards photoswitchable quadruple hydrogen bonds via a reversible "photolocking" strategy for photocontrolled self-assembly*, Royal Society of Chemistry (RSC), 2021.
- 4 M. Herder, M. Pa"tzelt, L. Grubert and S. Hecht, *Photoswitchable triple hydrogen-bonding motifwz*, 2011.

Business model innovation (BMI) in small enterprises during COVID-19 outbreak: Exploring drivers and BMI outcomes

Gabriel Martinez

Supervisory team: Suresh Renukappa and Subashini Suresh

Abstract The purpose of this paper is to provide understanding of driving forces for business model innovation (BMI) during the pandemic for small businesses in developing countries, comparing them with identified BMI drivers before the outbreak and evaluating how they adjust to the crisis. A qualitative multiple-case study is conducted as it allows the study of BMI within real life and contemporary context. Case study organisations that adopt innovative business models participated from technology, education, and social enterprises. Findings shows that small organisations are influenced by internal and external driving forces during the pandemic which play an important role in their BMI. Organisations showed resilience to the crisis adjusting accordingly to allow uninterrupted operation during lockdown and developing new products and services that would ensure sustained demand during COVID-19 pandemic. Lessons learned from this research could be useful for practitioners from developed and developing countries. Policymakers from developing countries could benefit from focusing their activities on promoting firms to find novel ways of operating during times of pandemic preventing further economic damage and unemployment. Since the contexts case study organisations operate share similarities in certain process with the construction sector, the practical implications could be useful for practitioners in that context. Furthermore, this paper discusses the future paths of research; including the potential of evaluating construction sector context.

Keywords Business model innovation, COVID-19, driving forces, small enterprises, developing countries

SDGs SDG 9 Industry, innovation, and infrastructure

Current year of study: Fourth year full time

Barriers to lean manufacturing in small businesses Experience of KRI-SMEs - Ibrahim Salih Mohammad, Dr. Daniel Emmanuel, Prof. Jyoh Louis

Name: Ibrahim Salih Mohammad

Supervisory team: Dr. Daniel Emmanuel, Prof. Jyoh Louis

Background: This paper examines the performance of manufacturing small business in the Kurdistan Region of Iraq (KRI) regarding main barriers that impede the successful implementation of lean tools and techniques.

Aim: The paper aims to investigate the awareness of lean approach and identify the main barriers to the implementation of lean strategies in Small and Medium-sized companies in the Kurdistan Region of Iraq (KRI-SMEs).

Methodology: Based on the critical review of literature related to difficulties that faced manufacturing SMEs in practising lean approaches and case studies in three SMEs in the KRI, barriers that impede effective lean implementation within manufacturing SMEs has been identified.

Results: The study identified practical barriers to lean practices among KRI-SMEs in eight dimensions which emerged from the three case studies conducted in the manufacturing sector.

Conclusion: The results raise the awareness of SMEs managers and practitioners who attempt to involve in lean journeys in their enterprise to avoid failures that could cause a vast loose in money, time and effort. The findings also could support SMEs in other developing countries that have similar business conditions as that of KRI.

Originality: This is the first study that explores lean practices and applied the multi-case studies method in the context of KRI. Additionally, the outcome this study enriches the literature of lean manufacturing within developing countries.

Keywords: Lean manufacturing, SMEs, barriers of lean, KRI

SDGs

The study comes in line with the following SDGs:

1. End poverty in all its forms everywhere: look at the business as opportunities that are productive and deliver a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom

for people to express their concerns, organize and participate in the decisions that affect their lives, and equality of opportunity and treatment for all women and men (Goal no.1).

2. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all (Goal no.8).

3. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation (Goal no.9).

4. Reduce inequality within and among countries (Goal no.10).

5. Ensure sustainable consumption and production patterns (Goal no.12).

5. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels (Goal no.16).

The fourth Industrial Revolution: technology challenges within construction industry. HJ

Author: Miss Haddy Jallow

Supervision team: Dr Suresh Renukappa and Dr Subashini Suresh

Abstract

Purpose

Over the past five years, there have been a lot of research on robotics, electronics, computer science and production engineering all relating to Industry 4.0. Although there have been quite a few publications on this in terms of general usage, there has been minimum consideration on mainstream topics such as Industry 4.0 technologies themselves. The publications that have been published currently are mainly focused on linking Industry 4.0 technologies to different aspects such as the link between Internet of things (IoT) and the supply chain management. In the past, there have been initiatives of increasing Industry 4.0 within projects, and it has been shown that over 2,000 companies have shown adoption of these technologies for various reasons, however, it is argued that some organisations have a very low production of automated processes this has been thought to be due to the fact that automated processes incur more costs hence organisations cannot justify the investment. Despite this, Industry 4.0 is being thought of as not just the integration of technologies but also takes into consideration future client demands. There is a lack of research within the use of these new upcoming technologies and the challenges to overcome and expect. Therefore this research aims to explore the challenges being faced in terms of these technologies within organisations and how these could be overcome.

Methodology

This research adopts a qualitative case study research methodology. 10 semi structured interviews were undertaken from 3 various organisations to collect data which is then analysed with the use of a thematic analysis method in order to draw out a conclusion.

Findings

Organisations have adopted some form of Industry 4.0 technology across the globe and have been investigating in using these technologies to improve their processes.

The use of these technologies can benefit organisations through automated processes cutting costs of staff and massively impacting health and safety as high-risk tasks can be undertaken these technologies with automation to avoid the risk of human staff members. These implementations and adoptions throughout these organisations have shown to provide more efficient processed and better current work practices.

Originality and value

This study will contribute to automation within the manufacturing industry. This paper explores and highlights the challenges being faced within organisations implementing and adopting Industry 4.0 technologies. Guidance on these challenges will be provided from lessons learnt by the case study organisations providing knowledge for more companies and organisations looking to implement these technologies. This will also assist organisations to get an enhanced process of implementation and adoption allowing all parties of the organisation to collaborate and communicate.

Key words: Industry 4.0, Construction Industry, Case study, Big data analysis, Internet of Things, Artificial intelligence (AI).

SDGs: 9 - Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Year of study: 3rd year

Use of Blockchain in Public Customized Business and Consumer Plastic Relationship Responsibility Efficiency Enhancement

AUTHOR: OTU, ABASIFREKE IFREKE

SUPERVISOR TEAM: DR. KEVAN BUCKLEY

ABSTRACT

The thesis highlights, observes and seeks to detail the use of blockchain technology particularly the identity of plastics as the saturated use is tiringly overlooked as it is in our toothbrushes, phones, takeaway & delivery containers, disposable utensils and even remote TV controls (GreenBiz, 2020). Due to the enormity of the plastic use, the chosen pathway is restricted to the customized business to consumer product relationship to amply fit within the boundaries of the research time frame and consonance with Sarah Nelen (European Commission – waste policy directorate) resonating fact affirming, “By 2030, 70% of packaging should be recyclable but more important is to look at material-specific targets with plastic packaging ‘more problematic’ to recover and recycle than cardboard boxes that are used by online shops”, courtesy of (Euractiv, 2018).

BACKGROUND

Hence a renewed innovative ethical profitable concerted focus is on the consumers by encouraging their participation in a decade new circular economy which seeks remedying focused activities in resource management from intensive usage to a more lasting extensive sharing of the same resource within an end to end loop cycle with special regard to customized business (food packages, plastic bottles and single-use shopping bags).

AIMS

Creating a template (developed blockchain program using python) for enhancing the responsibility of the ‘business and customer’ plastic relationship in the specified background above and where possible, a grafting to harness across in other areas within the plastic wide use if suited.

METHOD

Drawing upon the research theme, the three constants are matched with their respective enhancers in order aid measurability. Hence, the applicable implementation: ('Manufacturers and Producers' by virtue of 'Encompass and Encourage to Recycle), ('Customized Business' by virtue of 'Enforce and Encourage to Recovery), ('Consumer Efficiency' by virtue of 'Enlist and Encourage to Recovery').

METHODOLOGY

In the strength of the above method, three aspects of variables are created to cater for the above constants namely: (Selection, Connection and Explanation) where:

Selection: Is the choice of the chosen variables (Autocracy, Freedom and Order) which are necessary and related to the theme of the research and achieving the constant of an improved yield.

Connection: Is the appropriate fitting of the research to societal impact through an act of balancing (Science, Culture and Diplomacy).

Explanation: Is the vehicular language of communicating, convincing and cementing this body of work for worth of recommendation, critic, review and even approval for eventual use through the lanes of (Ethical Productivity, Brand Standard and Value Purchase).

RESULTS

Findings achieved so far point toward four pillars in society and with relative adaptors if this research is to enshrine its beneficial diligent goal of societal impact. Therefore, highlighting:

The economy – which the research gears to encourage.

The Law – which the research adheres to encompass.

The Diplomacy – which the research seeks to enlist.

The Culture – which the research portrays to enforce.

CONCLUSIONS

The research so far is a menu favouring a science filling together with a technology thrill, a culture filling together with a tourism thrill and a diplomatic filling together with an alliance thrill all garnished together for a flavouring recipe.

KEYWORDS

BLOCKCHAIN: A coded secured chain of record blocks” (Conference: World Blockchain Summit 2018).

CIRCULAR ECONOMY: A sustainable approach in resource management by shifting from an intensive usage model to an extensive sharing model minimizing waste.

CUSTOMIZED BUSINESS: A business which markets its own specific brand of goods.

CONSUMER EFFICIENCY: A culture of consumption with minimal or reduced detriment but increased assistance to production checking avoidable wastages.

SDGs:

Sustainable Development Goal 12 – Responsible Consumption and Production.

Link: <https://sustainabledevelopment.un.org/sdg12>

Year of study: 3rd year

SUSTAINABLE DEVELOPMENT GOALS

1 NO POVERTY



2 ZERO HUNGER



3 GOOD HEALTH AND WELL-BEING



4 QUALITY EDUCATION



5 GENDER EQUALITY



6 CLEAN WATER AND SANITATION



7 AFFORDABLE AND CLEAN ENERGY



8 DECENT WORK AND ECONOMIC GROWTH



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



10 REDUCED INEQUALITIES



11 SUSTAINABLE CITIES AND COMMUNITIES



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



13 CLIMATE ACTION



14 LIFE BELOW WATER



15 LIFE ON LAND



16 PEACE, JUSTICE AND STRONG INSTITUTIONS



17 PARTNERSHIPS FOR THE GOALS



Report from FSE Research Conference 2020

This report presents participant responses to a questionnaire on the United Nations Sustainability Development Goals (SDGs), sustainability awareness in general and awareness of Athena SWAN. Altogether 29 participants took part in the questionnaire. The first question asked whether or not participants were aware of UNs SDGs. 76% of participants were aware and of these 64% were aware through the University, 19% through work experience and 17% through other unknown means.

The second question explored whether sustainability could make difference to the natural world. 66% strongly agreed that sustainability could make a massive difference to the environment while 34% agreed and none of the participants expressed disagreement. As a follow up, the third question asked if sustainability had any impact on everyday life. All of the respondents agreed, 59% - stating that they strongly agreed and 41% - stating they agreed.

The next question requested participants to briefly explain what they understood by the phrase Sustainability. The answers to this typically involved how to responsibly use the resources available with the impact on society, economy and environment to save the future generations. 75% of the answers included the phrase 'to save the environment' and 'for future generations'.

To examine the practicality of sustainability, the next question requested participants to give an example where they had embraced or practised sustainability. The majority of answers included usage of reuse and recyclable products, with emphasis on plastic products (35%), reducing waste/waste management (20%) and usage of low carbon vehicles (15%). Some stated how 'sustainability' is embraced within their courses/research (25%). The remaining 5% included usage of clean energy, improved medications and feasibility projects.

The next question explored whether employers should expect new graduates to have knowledge of sustainability. Answers varied from strong agreement to disagreement. 56% strongly agreed, 41% agreed, 1% disagreed and the remaining 2% had no strong opinion. As a follow on from the previous question, participants were asked if the theoretical aspects of sustainability should be included in the course/curriculum/research. 99% were with agreement while 1% had no opinion. Participants were then asked about their willingness to be sustainability champions in their course/research. Following a similar pattern 98% agreed while 2% had no opinion.

Participants were asked whether the University should sign up to the UNs SDG Charter. The majority (98%) agreed. A follow up question asked participants about the advantages of UN SDGs. 22 of the 29 felt that it reflected creating an awareness to protect the environment and natural resources.

Regarding the question on embedding the UN SDGs into course/curriculum/research programme, it was thought it could be achieved via guest lectures, activities/seminars, conference and campaigns. Finally the participants were asked about Athena SWAN. The majority (71%) had no knowledge, but among those that had (29%) stated that Athena SWAN helps to promote and represent women, and generally progresses gender equality and helps in research areas.

There were two additional comments from participants which stated that: "without human personal cap on profits all useful sustainability will be hindered" and; "employees should not only require the knowledge, they should also embed sustainability into their other activities and cultures".