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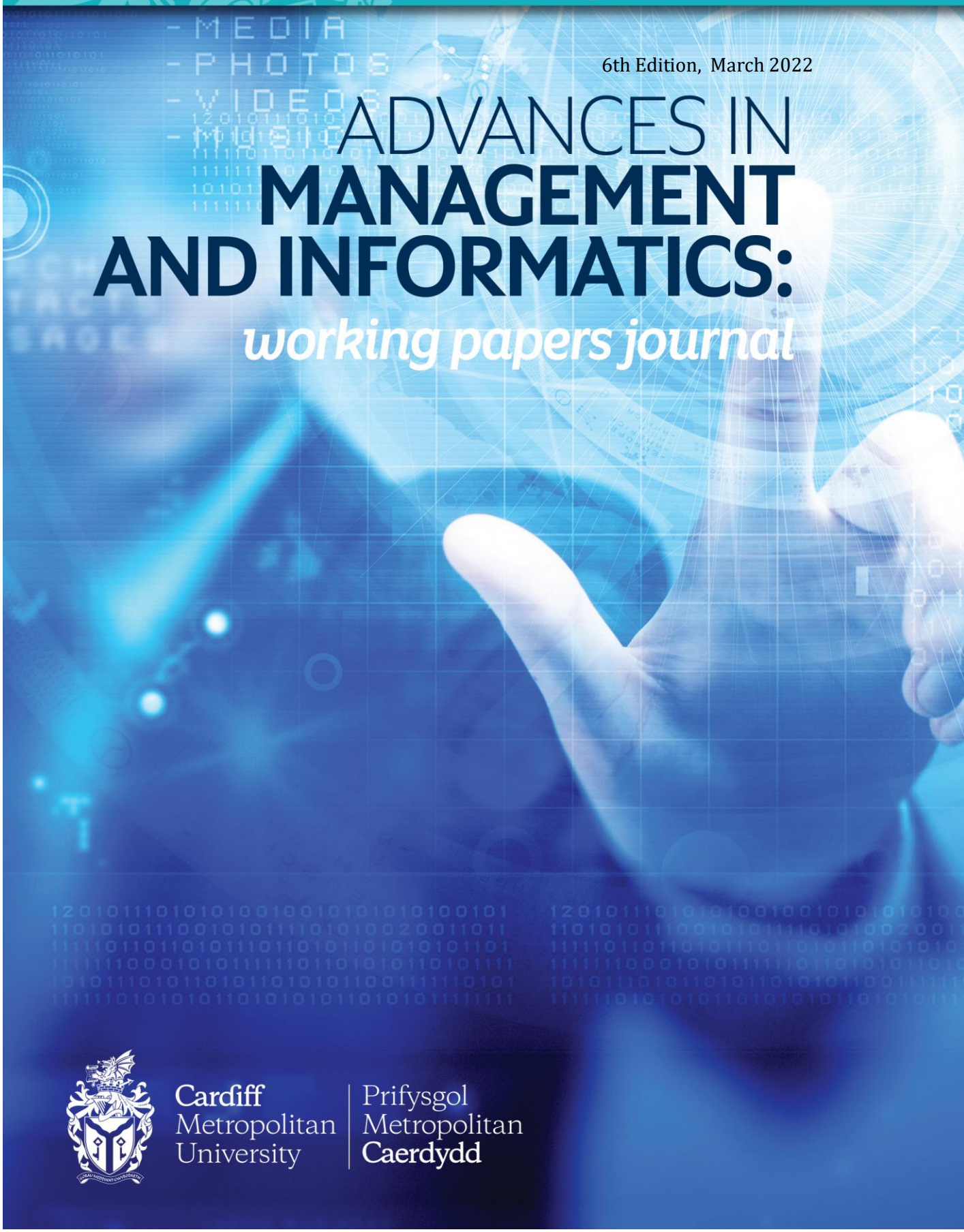

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Aims and Scope

Welcome to the sixth edition of the Advances in Management and Informatics (AMI) Journal. This is the edition includes the award-winning student paper from our AMI Conference in 2021.

Advances in Management and Informatics (AMI) is a journal that allows members of Cardiff School of Management to contribute topics of interest, ranging from embryonic ideas through to work that is nearing completion. Some of the ideas presented to the editor have since been published, and some are undergoing further research. We would like to stress that as this is a working paper journal, publication here does not preclude the authors from publishing their work elsewhere.

Editorial

This edition is pleased to present the 2021 AMI Conference Best Student Paper Prize Winner "Towards the Decarbonisation of Tourism: A Case Study of Ireland" by Anita Conefrey and James Hanrahan. This paper explores and discusses if the carbon footprint of tourism in Ireland has been assessed and therefore if there is a robust decarbonization strategy. The second paper explores the impact of the Covid19 situation on engagement and utilization of online learning tools. The paper discusses how this engagement with online learning approaches will impact learning and teaching in the future. Paper three focuses on the uncertainty visualisation, and it impact on decision making functions. The fourth paper in this edition researches the utilization of Machine Learning utilization within SME in order to Offer cyber security. Paper five presents research undertaken regarding the development of online financial market trading tools.

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Conference 2021 Best Student Paper Prize Winner

Towards The Decarbonisation Of Tourism:

A Case Study Of Ireland

Anita Conefrey and James Hanrahan

ABSTRACT

The purpose of this study was to identify to what level the carbon footprint of tourism has been discussed, assessed and planned for decarbonisation in Ireland. For this study, it was necessary to conduct a quantitative content analysis of Irish national plans. To identify if the carbon footprint of Irish tourism has been assessed, establish the methodological approach used to measure Irish tourism emissions, and determine what level of decarbonisation tourism strategies are in place. The findings in this study identified that the carbon footprint of Irish tourism has not been assessed and lacks serious discussion and planning for decarbonisation. As a result, tourism policymakers and destination planners cannot monitor and manage the level of tourism decarbonisation in Ireland if they are not measuring and reporting tourism emissions. Additionally, from conducting a comparative analysis of international tourism emission studies, it was determined that a unified approach needs to be agreed upon, as previously advocated by Sun (2014). Furthermore, the standard scope of impact needs to be established to ensure that each country measures the same criteria. Consequently, allowing policymakers and destination managers to compare international tourism emissions and establish if tourism is actively decarbonising. Climate change is a significant crisis facing humanity, and until now, this research has not been completed.

Keywords: Climate Change; Greenhouse Gas Emissions; Tourism Decarbonisation; Irish National Tourism Plans; Carbon Footprint; Analytical Approaches

INTRODUCTION

Currently, the world is facing a global health, social and economic emergency as a result of the COVID-19 pandemic. Policymakers, destination managers and tourism stakeholders have a major role in responding and adjusting to this challenging new environment, with a significant opportunity to explore and frame the new, post-COVID-19 sustainable strategies. Thus, building responsible tourism recovery plans.

Tourism is among the most affected industries with a massive fall in international demand due to slow virus containment, low traveller confidence and global travel restrictions (UNWTO, 2020). In May 2020, 75% of global destinations placed a complete stop on international tourism, and this caused extraordinary socio-economic impacts for the tourism industry. Tourism declined by 74% in international tourist arrivals during 2020, resulting in an estimated economic loss of over US$ 2 trillion in global GDP and risking nearly 120 million direct tourism jobs (OPSTP, 2020; UNWTO, 2020; UNWTO, 2021). There are additional environmental impacts, however, these are proving difficult to quantify at the moment. Nevertheless, the pandemic has raised the awareness of the crucial role sustainability needs to play in the responsible recovery of the tourism industry and the need to transform tourism operations. Climate action continues to be of utmost importance for tourism.

Pre COVID-19, there was an increase of awareness and attention on the need for assessing the carbon footprint of tourism at national and regional levels, globally (Patterson & McDonald, 2004; Beckan & Patterson, 2006; Grimm et al., 2008; Perch-Niesen et al., 2010; Dwyer et al., 2010; Hoque et al., 2010; Konan & Chan, 2010; Farreny et al., 2011; Filimonau et al., 2013; Sun, 2014; Cadarso et al., 2014; Sanyé-Mengual et al., 2014; Björnsson, 2014; Sharp et al., 2016; WAWRG, 2018; Rico et al., 2019; Kitamura et al., 2020). It is vital that the carbon footprint of tourism is assessed and understood so that the state government can make evidence-based decisions when preparing appropriate and destination-specific tourism decarbonisation plans and strategies. Additionally, by measuring and reporting the carbon footprint of tourism, policymakers and destination managers can easily monitor and compare the impact of tourism emissions internationally. Thus, ensuring the tourism industry is actively transitioning towards a sustainable and low-carbon industry.

Despite many experts proclaiming the importance of measuring the carbon footprint of tourism, many global emission reduction plans continue to ignore the tourism industry. Moreover, there are many analytical approaches used to assess the carbon footprint of tourism. For example, the bottom-up approach measures the emissions from the micro-systems, whilst the top-down approach measures the emissions from the macro-systems. Often, many international tourism carbon footprint studies have combined both of these approaches to create a hybrid approach that accounts for the full scope of tourism emissions (Patterson & McDonald, 2004; Beckan & Patterson, 2006; Hoque et al., 2010; Perch-Niesen et al. 2010; Dwyer et al., 2010; Filimonau et al., 2013; Sharp et al., 2016; Kitamura et al., 2020). Previous researchers have stated that the hybrid approach is superior as it combines the data and the strengths from the bottom-up and

top-down approaches. Thus, the hybrid approach overcomes the limitations and uncertainties of using only one approach.

Most human activities require energy directly or indirectly from the combustion of fossil fuels or the removal of carbon sinks (i.e., forests or peatlands). Therefore, these activities lead to the creation of anthropogenic greenhouse gas emissions, resulting in climate change impacts (Dwyer & Spurr, 2010; Sharp et al., 2016). Climate change and tourism have adverse effects on each other, and like all other industries, tourism is expected to make necessary emission reductions. Pre COVID-19, tourism was thriving globally, with 1.5 billion international tourist arrivals in 2019, a 4% increase from 2018, which was also predicted for 2020. Lenzen et al. (2018) estimated that the tourism industry is responsible for 8% of the overall global emissions. In 2013, it was estimated that tourisms annual carbon footprint was 4.5 Gigatons of Carbon Dioxide Equivalent (GtCO2eq), and it was expected to reach 6.5 GtCO2eq by 2025. UNWTO (2020) has urged that this growth needs to be managed sustainably to seize the opportunities tourism generates. However, it remains uncertain what form tourism will take post-COVID-19, and it is a matter of critical debate as decarbonising industries to transition towards a low-carbon economy is the other major crisis humanity faces. Nevertheless, there is a considerable amount of encouragement for tourism policymakers, destination managers and tourism stakeholders to view the recovery from COVID-19 as an opportunity to develop tourism more sustainably. With a particular focus on tourism recovery plans to prioritise measuring and reporting tourism emissions at a national level.

The first purpose of this study was to identify if the carbon footprint of Irish tourism has already been established and planned for decarbonisation in Ireland, pre-COVID-19 and post COVID-19. The second purpose of this study was to determine if a baseline carbon footprint figure can be generated for international tourism pre-COVID-19. Whilst also establishing if there is a unified analytical approach to measure tourism emissions globally. For this study, a quantitative content analysis of Irish national plans was implemented to identify if the carbon footprint of tourism has been assessed and to determine what level of tourism decarbonisation strategies are in place in Ireland. In addition to this, a comparative analysis of international tourism carbon footprint studies was implemented to establish any similarities or differences in the assessments. Consequently, determining a unified analytical approach to measure tourism emissions.

LITERATURE REVIEW

The current theory from international literature has been discussed in the context of assessing the carbon footprint of Irish tourism pre and post COVID-19. Initially, this provides background data on Ireland's greenhouse gas emissions and the performance of the Irish tourism industry to date. Before highlighting the current national plans that are in place to mitigate climate change impacts and aid the responsible recovery of tourism. Based on observations, the understanding of the different analytical approaches is interpreted along with an example of the approaches being implemented in other international studies at national or regional levels. Therefore, identifying if there is a unified approach used to assess the carbon footprint of tourism.

Tourism, Climate Change and COVID-19

Tourism has been severely struck by COVID-19. Some believe the pandemic has opened the doors for how post-pandemic tourism recovery could serve as a catalyst for sustainable tourism transformation. However, this has been discussed for many years but has still failed to be implemented (Chang, McAleer and Ramos, 2020; Scott, 2021; Sharma, Thomas and Paul 2021). The UNEP and UNWTO (2005) state that sustainable tourism must take full account of its economic, social and environmental impacts. Sustainable tourism development is a continuous process that requires the informed participation of all relevant stakeholders, strong political leadership, constant monitoring of impacts and necessary mitigation and adaptive strategies.

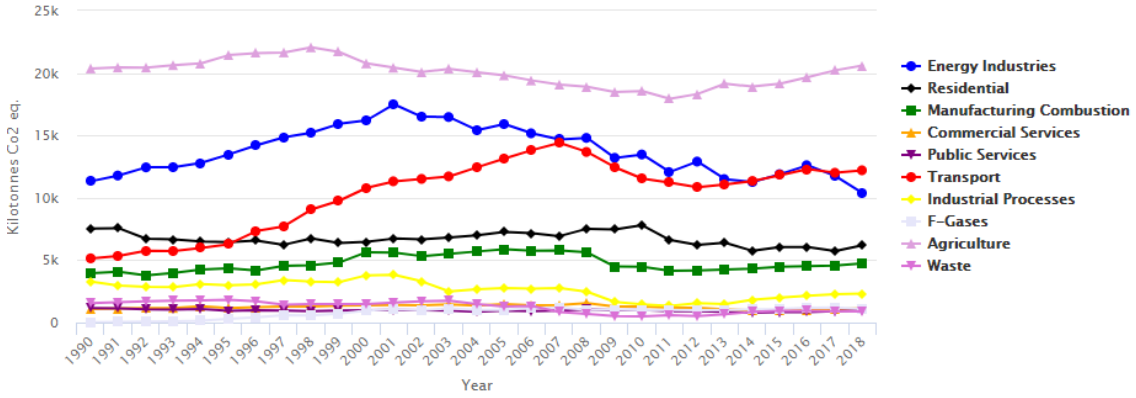
With the development of vaccines, a post-COVID-19 pandemic era can be foreseen, however, the same cannot be said of the climate change crisis. Consequently, it is vital that stakeholders (public and private) and world leaders collaborate together to strive for sustainable tourism development in post-pandemic tourism recovery plans. The first climate change challenge faced by tourism is the transition towards a low-carbon industry. Thus, it is crucial to decarbonise tourism to achieve the Paris Climate Agreement ambitious emission reduction targets. As a result, tourism cannot be considered sustainable if it fails to decarbonise the industry to mitigate climate change (Scott, 2021). Hence, tourism policymakers and destination managers need to establish the carbon footprint of tourism at a national level to generate and implement destination-specific decarbonisation strategies for sustainable tourism development.

The One Planet Sustainable Tourism Programme (2020), which contributes to the Sustainable Development Goals and the Paris Agreement, aims to support the development and implementation of responsible tourism recovery plans. One Planet intends to enhance the resilience of tourism by balancing the needs of people, the planet and prosperity. Their vision recommends six lines of action to guide this tourism recovery, with climate action being one of them. Their recommended strategies for climate action are monitoring and reporting tourism emissions, accelerating the decarbonisation of tourism operations, and engaging the tourism industry in natural and technological carbon removal methods. For years, many experts have highlighted the importance of understanding the role of tourism and emissions to combat climate change. But global analysis and reduction plans continued to ignore the tourism industry (Dwyer & Spurr, 2010; Sharp et al., 2016; Rico et al., 2019; Dogru et al., 2019; Scott, 2021). Ireland is vulnerable to climate change impacts such as sea-level rise, increased storm frequency and changing precipitation patterns (Department of Communications, 2015; Climate Change Advisory Council, 2019). The need to assess the carbon footprint of tourism to plan for climate change mitigation and develop tourism sustainability is essential for the recovery and resilience of tourism post-COVID-19.

Global demand for air travel has grown by 60% over the last ten years due to higher incomes, higher levels of education, population growth and urbanisation. Aviation represents between 1.7% - 2.3% of global Carbon Dioxide (CO2) emissions (Becken & Shuker, 2019). In 2019, Ireland's overseas tourists reached nearly 9.7 million (+0.7% increase from 2018). The largest overseas tourism markets remain to be North America, Mainland Europe and Great Britain, which mainly arrive to Ireland by air travel (89%). Tourism offers significant economic and social benefits to the Irish economy, with €9.5 million generated in revenue in 2019 and directly employing approximately 260,000. Nevertheless, the level of dependency on the aviation sector for overseas markets can be extremely worrying for Ireland's national emissions (Fáilte Ireland, 2019; Fáilte Ireland, 2021). Transport is considered the highest contributor to emissions, however, other tourism-related activities can also contribute significantly high emissions due to their high energy intensity. For instance, the accommodation sector, leisure activities such as shopping, and food and beverages (Lenzen et al., 2018; Rico et al., 2019). In Ireland, agriculture, transport, and energy are the highest emitting sectors, and they also play a vital role in the tourism industry. Therefore, as tourism is an integrated multisectoral industry, measuring and reporting tourism emissions with a breakdown of emissions from each sector involved in the tourism offering is necessary.

In 2019, global tourism emissions were set to increase by at least 25% by 2030. However, as international travel came to a halt during the pandemic, it is estimated that global emissions will have declined by 8% (OPSTP, 2020). Ireland's greenhouse gas emissions were estimated to be 60.51 Million tonnes CO2eq (MtCO2eq) in 2018, which is lower than emissions in 2017. Nevertheless, this decrease only occurred in three sectors: energy industries, waste and F-gases. Whilst, greenhouse gas emissions had increased in other sectors, as seen in figure 1.

Figure 1. Greenhouse gas emissions share by sector in 2018 provisional estimates

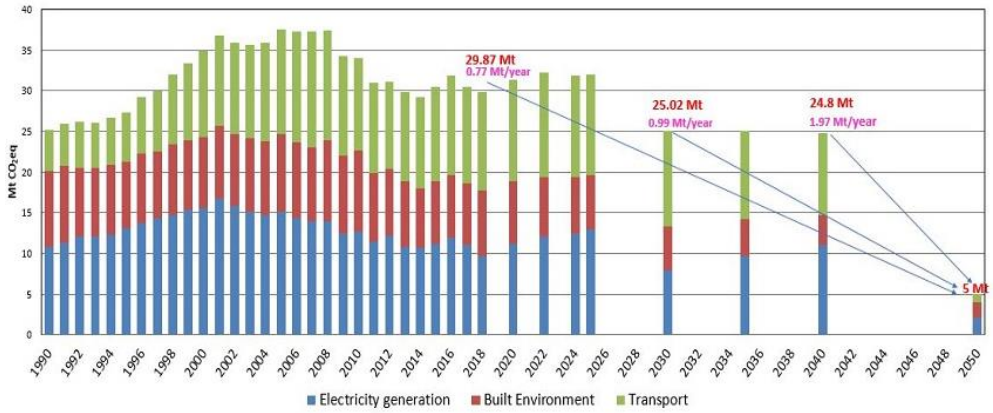


Sourced: EPA (2020)

Under the European Union, Ireland must reduce emissions by 30% by 2030. Since 2016, Ireland has continued to breach the European Union reduction targets, and the carbon budget will be exceeded over the period 2021-2030 (EPA, 2020). Although it is estimated that COVID-19 has caused almost a 6% reduction in national greenhouse gas emissions, any economic rebound from the pandemic could bring emissions back to previous levels (McCormack, 2021). Hence, if emissions resume to pre-COVID-19 levels, going forward, the state will be penalised by the European Union for not meeting the reduction targets in 2030. Additionally, Ireland's long-term decarbonisation goals will be extremely difficult to achieve.

Ireland's national policy plans state the ambitious long-term vision of transitioning towards a low-carbon economy by reducing emissions by 80% in 2050 (Government of Ireland, 2015; Government of Ireland, 2017; Government of Ireland, 2019; EPA, 2020). The extent of the challenges ahead and the need for drastic reductions immediately to achieve the ambitious vision by 2050 is visible in Figure 2.

Figure 2. Emissions reduction required per annum to meet the 2050 target based on 2019 projections



Sourced: EPA (2020)

This theory suggests the need to assess the carbon footprint of all industries to empower the Irish government in identifying whether all industries are equally committed to decarbonising. Additionally, the state government can compare the carbon footprint of tourism against international tourism emission studies. Once the carbon footprint is understood, appropriate and realistic emission reduction goals for tourism can be assimilated and implemented.

Carbon Footprint

Recently, the carbon footprint term has increased in public appearance and is used regularly to debate emission reduction action against climate change (Wiedmann & Minx, 2008). The carbon footprint is an accounting assessment tool to determine how carbon-intensive production and consumption of goods and services are within an industry. It allows areas of high emissions to be identified, managed, and eliminated or reduced (Dwyer & Spurr, 2010; Rico et al., 2019). The carbon footprint offers a comprehensive method to measure emissions as it puts a weight number on the environmental impacts human activities cause. Consequently, it involves collecting activity data from each emission source and converting it into emission levels (Dwyer et al., 2010). The carbon footprint of tourism can be assessed at many levels: a single tourism product, individual tourists, individual operators, industry sectors, and at regional, national, and global levels.

- *Carbon Footprint Measurements*

Tourism produces direct and indirect greenhouse gas emissions through its purchases of goods and services. Generally, there are two units of measurement for carbon footprint assessments, firstly carbon alone (CO2) and secondly, the six most malicious greenhouse gases known as carbon equivalent (CO2eq) (Björnsson, 2014). Direct emissions are generated directly from tourist activities. It is argued that by only assessing CO2, only the direct emissions are

measured (Dwyer & Spurr, 2010; Sharp et al., 2016). Therefore, it is recommended that carbon footprint measurements assess all greenhouse gas emissions in the form of CO2eq. Including the indirect emissions, as they can be much higher.

Indirect emissions are a result of intermediate input due to other emission causing activities related to the industry, usually embedded in international trade (Sharp et al., 2016). Excluding indirect emissions would underestimate the total carbon footprint generated by tourism, as they include emissions linked to electricity. For example, heating, air-conditioning, lighting, cooking, and growing food products in hotels (Sun, 2014; Cadarso et al., 2016). It is estimated that CO2 has a life expectancy of 100 years in the atmosphere. So, CO2eq weighs all the greenhouse gas emissions using CO2's 100-year life expectancy. Furthermore, CO2eq is the standard international unit of measurement, as it is used in most international agreements, such as the *United Nations Framework Convention on Climate Change* and Kyoto Protocol (Björnsson, 2014). Thus, to fully understand the environmental impact of tourism, it is necessary to measure the direct and indirect emissions. Additionally, assessments need to maintain the standardised CO2eq measurement to ensure international carbon footprints can be easily compared and monitored regularly.

Analytical Approaches to Measure the Carbon Footprint of Tourism

Within the literature, there are the options of three analytical approaches and toolkits for assessing the carbon footprint of the tourism industry:

1. Carbon calculators and toolkits: the European Tourism Indicator System (ETIS) toolkit and recommended carbon footprint calculators.
2. Comprehensive approaches: the bottom-up approach, which is combined with the Life-cycle analysis (LCA) or the top-down approach, which is based on Environmental Input-Output (EIO) analysis.
3. Hybrid approaches: a combination of both bottom-up and top-down approaches.

Carbon calculators and toolkits

These calculators and toolkits are already available online for users to enter their data or download formulas. The European Union created ETIS to encourage destinations to adopt a more intelligent, sustainable approach to tourism planning. The ETIS helps manage and monitor sustainability in destinations and is deemed useful for policymakers, destination managers, and other tourism stakeholders (European Union, 2016). The indicators are

categorised into destination management, economic impact, social and cultural impact, and environmental impact. This study focuses on the environmental impacts, as seen in Figure 3.

Figure 3. The environmental impacts from the ETIS toolkit

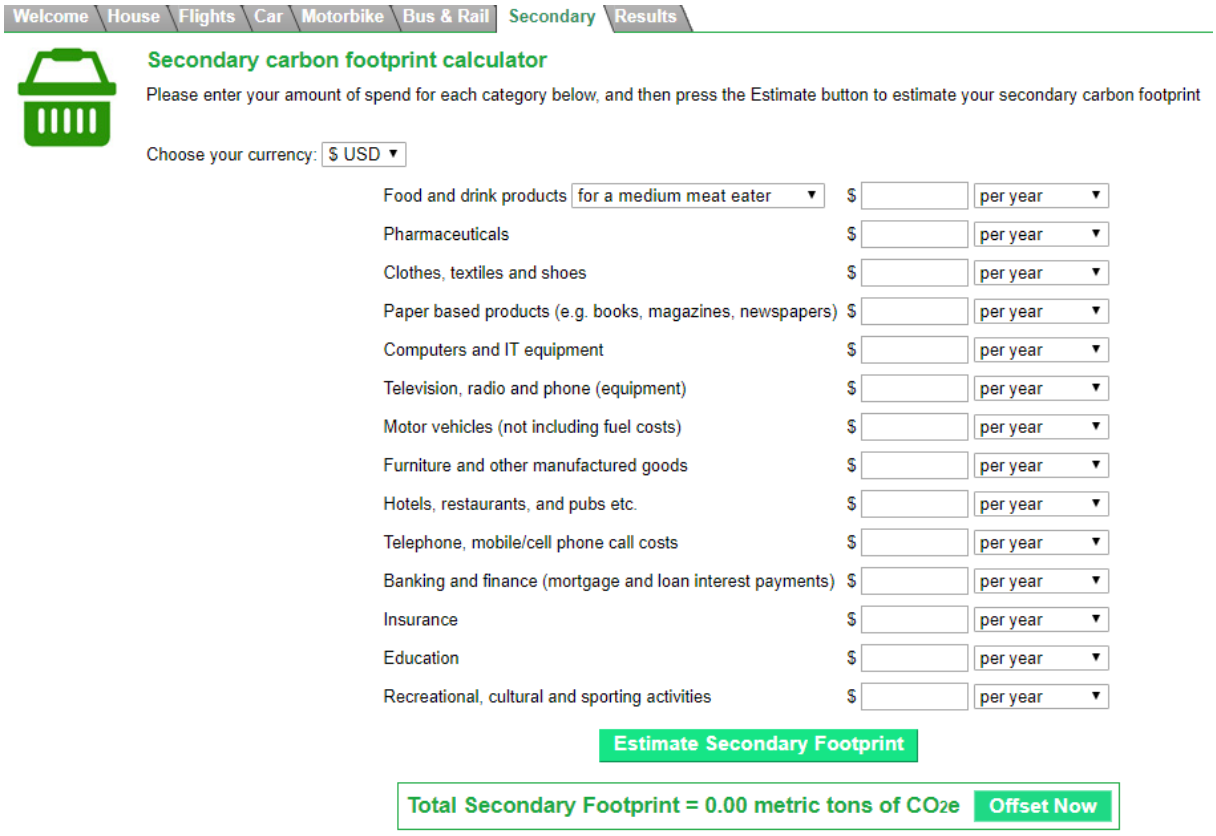
Section D: Environmental impact		
Criteria	**Indicator reference#**	**ETIS core indicators**
D.1 Reducing transport impact	D.1.1	Percentage of tourists and same-day visitors using different modes of transport to arrive at the destination
	D.1.2	Percentage of tourists and same-day visitors using local/soft mobility/public transport services to get around the destination
	D.1.3	Average travel (km) by tourists and same-day visitors from home to the destination
	D.1.4	Average carbon footprint of tourists and same-day visitors travelling from home to the destination
D.2 Climate change	D.2.1	Percentage of tourism enterprises involved in climate change mitigation schemes — such as: CO_2 offset, low energy systems, etc.— and 'adaptation' responses and actions
	D.2.2	Percentage of tourism accommodation and attraction infrastructure located in 'vulnerable zones'

Sourced: European Union (2016)

The benefits from this toolkit include pre-developed surveys, destination profiles and datasheets, and formulas to facilitate the measurements. However, the limitations of this toolkit include that the carbon footprint measurement only focuses on direct transport CO2 emissions. This toolkit was previously attempted in Ireland to get the carbon footprint of tourists arriving at the regions Clare, Sligo and Donegal (Harahan et al., 2018). However, this toolkit was found to be problematic, so the Environmental Protection Agency's recommended carbon calculator was utilised instead.

The Environmental Protection Agency recommends three carbon calculators for personal, businesses, institutions and local authorities to use. The calculators' highlight areas that have the most significant effect on climate change and offer advice on how to reduce or offset your carbon footprint (One Planet, 2018; EPA, 2020). The *Carbon Calculator* is more comprehensive than the *WWF calculator* and uses the greenhouse gas emission factors produced from DEFRA 2017 Supply Chain to assess emissions. DEFRA was initially designed for businesses in the UK to use, however, the scope of application has dramatically extended to several other European countries, Australia and New Zealand (Filimonaua et a.l, 2011). Additionally, the *Carbon Calculator* measures the carbon footprint of aviation, transport and secondary expenditure (i.e., hotels, pubs and restaurants, retail and recreational, cultural and sporting activities) in CO2eq. These are the main sectors in the tourism industry, as seen in Figure 4.

Figure 4. Carbon calculator measures transport, home, and secondary emissions



Source: Carbon footprint (2020)

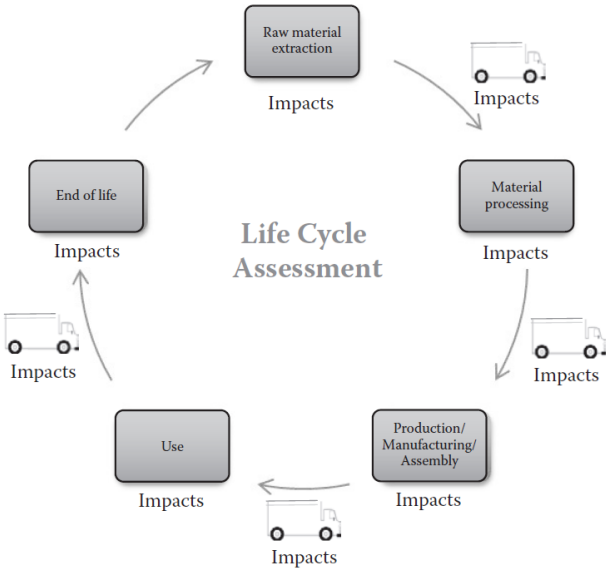
This calculator was used to measure the carbon footprint of transport in specific regions in Ireland (Hanrahan et al., 2018). The WWF calculator was used to measure the carbon footprint of German tourists to specific destinations (Grimm et al., 2008). However, the WWF calculator is limited to direct emissions only. Whilst the Carbon calculator is limited to assessing only some of the indirect emissions. The CARMACAL calculator won an award for innovation from UNWTO and WTTC (One Planet, 2018). It is a business-orientated calculator for tour operators, travel agencies or entire destinations, measuring direct and indirect emissions. However, this calculator can be expensive.

- *Bottom-up approach and Life-Cycle Analysis*

The bottom-up approach is consistent with the consumption-based view of greenhouse gas emissions accounting and is usually based on process analysis. This approach is very data-heavy, time-consuming and requires more resources, but as a result, it has a high level of accuracy (Becken & Patterson, 2006; Vuuren et al., 2009; Lin et al., 2013; Björnsson, 2014). Perch-Niesen et al. (2010) found it to be the most accurate approach as it focuses on details from the energy system and insights into technology development. Tourists actual behaviour is the centre of this approach. This approach has clear advantages for looking at micro-systems

but lacks macro-economic feedback (Vuuren et al., 2009; Lin et al., 2013; Sun, 2014). This approach alone was implemented to assess the carbon footprint of Antarctica and Iceland (Farreny et al., 2011; Björnsson, 2014). However, these studies were limited to direct emissions and did not analyse the full scope of impact from tourism emissions. Therefore, it is recommended to combine the bottom-up approach with the Life-cycle analysis, as they share the same characteristics. Nevertheless, the Life-cycle analysis is more comprehensive. It evaluates the direct and indirect emissions based on the environmental damages associated with the production, use, and disposal of a product or service, as seen in Figure 5.

Figure 5. Life cycle assessment concept



Sourced: (Franchetti & Apul, 2012)

Furthermore, the life-cycle analysis can estimate the carbon footprint of a person, industry, organisation, community or entire nation (Franchetti & Apul, 2012). Barcelona City assessed the direct and indirect emissions with this approach and used the ISO 14040:2006 data (Rico et al., 2019). The ISO 140672018 (updated version) provides globally agreed principles, requirements, and guidelines for the quantification and reporting of the carbon footprint of a product (Naden, 2018; The International Organisation for Standardisation, 2018). It has been accepted as the International Standard.

- *The Top-down approach and Environmental Input-output Analysis*

The top-down approach is usually built on the environmental input-output analysis and focuses on a more comprehensive economic context of the entire economy. Consequently, it requires knowledge of specialised matrix calculations using monetary information (Vuuren et al., 2009). For example, the Tourism Satellite Accounts exists in over 70 countries worldwide and is internationally recommended. It is a statistical tool that keeps track of the demand for goods

and services linked to tourism. The Tourism Satellite Accounts are used as the economic data against environmental accounts, estimating direct and indirect emissions. The Tourism Satellite Accounts were generated from the *System of National Accounts* from 1993, which the *Commission of the European Communities, International Monetary Fund, Organisation for Economic Cooperation and Development, United Nations* and the *World Bank* encouraged, and UNWTO approved (Dwyer & Spurr, 2010; Björnsson, 2014; Sun, 2014). This approach is considered to be less time consuming and superior for the macro-systems: industrial sectors, individual businesses, larger product groups, and government.

However, there are limitations to assessing macro-systems, such as not having enough detailed information to monitor minor changes. As a result, it neglects the use and end-of-life phases in the life-cycle of products or services. Furthermore, there are issues of incompleteness, truncation errors and that it is based on historic tourist behavioural evidence. Consequently, assuming historic tourism behaviour to be still relevant for future systems (Vuuren et al., 2009; Lin et al., 2013). Perch-Niesen et al. (2010) found this approach to be inaccurate in Switzerland compared to the bottom-up approach. Nevertheless, Hawaii and Spain found this approach useful to assess the carbon footprint (Konan & Chan, 2010; Cadarso et al., 2015). Subsequently, if a destination is listed on the Tourism Satellite Accounts, then this approach is useful for assessing the carbon footprint of tourism. Unfortunately, Ireland does not appear on Tourism Satellite Accounts. Thus, there are barriers to implementing this approach internationally.

- *Hybrid Approach*

A hybrid approach is sometimes considered to be the best approach as it combines the data and strengths from the bottom-up and top-down approaches. For example, it is improving the accuracy of carbon footprint calculations by replacing monetary data with physical data to solve the problem of price heterogeneity. In addition, this allows tourists actual behaviour (distance travelled, nights stayed) to be better modelled within the input-output framework (Becken and Patterson, 2009; Lin et al., 2013; Sun, 2014; Sharp, 2016). There is evidence of many destinations implementing a hybrid approach to assess the carbon footprint of tourism, such as Australia, Switzerland, Taiwan, Iceland, Spain and even the global tourism emissions (Dwyer & Spurr, 2010; Sun, 2014; Sharp et al., 2016; Cadarso et al., 2016; Lenzen et al., 2018). Adopting a hybrid approach for tourism will reduce estimation errors, especially concerning the treatment of aviation and accommodation, by modelling flight miles and room nights instead of monetary units.

The literature gives valuable insight and understanding on the importance of measuring and reporting tourism emissions to enable tourism policymakers and destination managers to make an evidence-based decision regarding the decarbonisation of tourism. Furthermore, the literature highlights the advantages and limitations of the different analytical approaches and toolkits previously implemented in international tourism carbon footprint studies.

METHODOLOGY

The research methodologies conducted within this study comprises a quantitative content analysis of Irish national plans and a comparative analysis of international tourism carbon footprint studies. As a result, this study utilises publicly available secondary data. Content analysis is a scientific tool and the only research methodology used to determine textual meaning (Krippendorff, 2004). The analysis draws conclusions from certain premises and samples through inductive, deductive or abductive processes (Gheyle & Jacobs, 2017). This analysis can have a quantitative or qualitative approach. Quantification is essential in many scientific studies and is a deductive process that is categorised by a priori coding scheme, then described using statistical tools. In contrast, qualitative is an inductive process that has proven successful, particularly in political, psychotherapeutic, ethnographic, discourse and computer text analysis (Krippendorff, 2004; Gheyle & Jacobs, 2017). The analysis is not pre-defined and requires the construction of categories whilst reading through texts, and then these findings are coded. This research conducted a quantitative content analysis of major Irish national plans to determine the current state of play concerning the carbon footprint of Irish tourism. The content was extracted and categorised. With the aim of identifying to what level the carbon footprint of Irish tourism has been discussed, assessed and planned for decarbonisation by the state.

Additionally, a comparative analysis is used to understand the complex phenomenon by identifying similarities and differences in studies (Rihoux & Ragin, 2009) Hantrais (2009) states that a comparative analysis is widely employed to systematically compare studies of societies, countries, cultures, systems, institutes, social structures and change over time. For this study, a comparative analysis of international studies was completed to distinguish similarities and differences between international tourism carbon footprint studies, both at a regional and national level. As a result, identifying if there is a baseline carbon footprint of tourism by comparing international data. Thus, determining which analytical approach will work best for assessing the carbon footprint of Irish tourism.

FINDINGS AND DISCUSSION

According to Scott (2021), tourism plans lack climate change content and decarbonisation strategies. Therefore, a quantitative content analysis of relevant Irish National plans was conducted to determine the extent of how many national plans and tourism plans in Ireland discuss, asses or plan for tourism decarbonisation, as seen in Table 1. The content that was related to climate action was extracted from the 35 Irish national plans and categorised accordingly, as illustrated in Table 2.

Table 1. A quantitative content analysis of Irish national plans

National Discussions and Plans in Ireland	
The Irish Government	
Tourism Recovery Plan 2020 - 2023	(TRTF, 2020)
Tourism Action Plan 2019-2021	(DTTS, 2019)
Climate Action Plan 2019	(DECC, 2019)
Project Ireland 2040 2019	(Government of Ireland, 2018)
Project Ireland 2040 The First Year: Annual Report 2018	(Government of Ireland, 2019)
National Mitigation Plan	(DCCAE, 2017)
Ireland's Transition to a Low Carbon Energy Future 2015- 2030	(DCENR, 2015)
People, Place and Policy: Growing Tourism to 2025	(DTTS, 2015b)
National Energy Efficiency Action Plan 2017-2020	(DCCAE, 2017)
National Peatland Strategy: Progress Report 2017	(DCHG, 2018)
National Biodiversity Action Plan 2017-2021	(DCHG, 2017)
A National Aviation Policy for Ireland	(DTTS, 2015a)
National Renewable Energy Action Plan	(Government of Ireland, 2009)
Bioeconomy Implementation Group: First Progress Report	(DCCAE &DAFM , 2017)
Climate Change Advisory Council	
Annual Review 2019	(CCAC, 2019)
Fáilte Ireland	
Fáilte Ireland Tourism Destination Towns Guidelines	(Fáilte Ireland, n.d)
Fáilte Ireland Climate Change: Our Carbon Strategy 2012	(Fáilte Ireland, 2012)
Fáilte Ireland & Heritage Council: Climate Change, Heritage & Tourism 2009	(Fáilte Ireland, 2009)
Fáilte Ireland Ecotourism Handbook	(Fáilte Ireland, 2009)
Fáilte Irelands Green Marketing Toolkit 2011	(Fáilte Ireland, 2011)
Fáilte Ireland a Strategy for Investment 2016-2022	(Fáilte Ireland, 2016)
Fáilte Ireland Environmental Sustainability in Business	(Fáilte Ireland, n.d)
Fáilte Ireland Driving Tourism Sustaining Communities 2017	(Fáilte Ireland, 2015)
Fáilte Ireland Ecological Survey 2018	(Fáilte Ireland, 2019)
Fáilte Ireland Food Tourism Activity Plan 2014-2016	(Fáilte Ireland, n.d)
Visitors Attitudes on the Environment 2008	(Fáilte Ireland, 2012)
Fáilte Ireland Reducing your utility costs in 2012 Can you afford not to?	(Fáilte Ireland, 2012)
Water Management Minimisation Good Practice Guide 2018	(Fáilte Ireland, n.d)
Fáilte Ireland Annual Report 2018	(Fáilte Ireland, 2019)
Fáilte Ireland Annual Report 2017	(Fáilte Ireland, 2018)
Fáilte Ireland Annual Report 2016	(Fáilte Ireland, 2017)
Irish Tourism Industry Confederation	
Tourism an Industry Strategy for Growth to 2025	(ITIC, 2018)
Environmental Protection Agency	
Ireland's National Inventory Report 2019	(EPA, 2019)
Sustainable Tourism Development	(EPA, 2007)
Personal & Household Carbon Calculators 2020	(EPA, 2020)

Table 2. Categorised content extracted from Irish national plans

Constructed Category	Extracted Content	Percentage of plans that mention extracted content
Tourism	Carbon Footprint of Irish Tourism	0%
	Decarbonise Tourism	0%
	Sustainable Tourism	51%
Economy	The Government involvement (e.g., investment, policy, regulations etc.)	71%
	Local Authorities involvement	69%
	Circular Economy	11%
	Carbon Neutrality/ Low Carbon Economy	46%
	Sharing Economy	11%
	Bioeconomy	17%
	Educate / Training/ Research	77%
	Collaboration for sustainability	60%
Planning	Short-term Planning	43%
	Long- term Planning	74%
Climate Change/ Emissions	Climate Change Mitigation & Adaptation Strategies	54%
	Biodiversity	43%
	Greenhouse Gases	49%
	Environmental impacts	66%
	EU Emissions Trading Scheme (ETS)	26%
Carbon	Carbon Policy/ Regulation & Legislation/ Practice	69%
	Carbon Footprint	29%
	Carbon Management	14%
	Carbon Offsetting	14%
	Decarbonising	26%
	Carbon Capture/ Storage / Sink	29%
	Carbon Sequestration/ Absorption	26%
	Carbon Budget	17%
	Carbon Tax/ Pricing	20%
	Carbon Credits	9%
Technology, Infrastructure, Energy	Reduce Water, Energy and Waste Consumption	34%
	Low Carbon/ Sustainable Renewable Technology	46%
	Low Carbon/ Sustainable Buildings/ Infrastructure	40%
	Low Carbon/ Sustainable Funding/ Investment/ Mortgages	23%
	Retrofitting	26%
	Renewable Energy/ Heat/ Bioenergy	40%
Transport	Aviation Emissions Reduction Solutions	20%
	Reduce Travel Distance	14%
	Sustainable Mobility	11%
	Veloroutes/ Bike Lanes	9%
	Walking Routes	14%
	Reduce Reliance on Cars/ Car Traffic	14%
	Electric Vehicles	23%
	Alternative Fuel (Bio, Hydrogen)	31%
	Car Sharing	6%
	Public Transport	43%
	Zero Carbon Public Transport	14%
	Blueways	14%
	Greenways	34%
Consumers	Change Behaviour & Attitudes	40%
	Dietary Change	11%
	Sustainable Production, Management, Purchasing & Consumption	49%
Agriculture	Sustainable Agriculture/ Food Production	26%
	Agriculture Impacts	20%
	Agricultural Diversification	17%
	Holistic Planned Grazing	9%
	Forestry/ Afforestation/ Reforestation	40%

Initial findings from the quantitative content analysis indicate a serious gap in knowledge as the carbon footprint of Irish tourism has not been assessed and lacks serious discussion. Thus, confirming the theory that emission reduction plans and recovery plans continue to ignore the tourism industry (Dwyer & Spurr, 2010; Sharp et al., 2016; Rico et al., 2019; Dogru et al., 2019). Only four national plans discuss sustainable tourism. Consequently, the Irish tourism industry lacks the appropriate and necessary knowledge to implement realistic and destination-specific decarbonisation strategies. Furthermore, this finding confirms that Ireland's vision to transition towards a low-carbon economy by 2050 will be challenging to achieve (Government of Ireland, 2015; Government of Ireland, 2017; Government of Ireland, 2019; EPA, 2020). For the Irish economy to make this transition, national plans and national tourism plans need to provide transparent and adequate information to inform the decarbonisation of tourism.

According to Scott (2021), tourism cannot be considered sustainable if it fails to decarbonise the industry to combat climate change. In 2012, Fáilte Ireland stated their intention to assess the carbon footprint of Irish tourism, however, there has been no evidence of this assessment to date (Fáilte Ireland, 2012). Fáilte Ireland continuously advocates for sustainable tourism development, with 70% of their tourism plans mentioning sustainable tourism. Thus far, there is very little evidence and a severe lack of detailed discussions around the opportunities and strategies to decarbonise the Irish tourism industry. Moreover, there is very little information available, incentives or plans in place to influence the desired behavioural change from Irish tourists and tourism stakeholders; to assess, reduce or offset their carbon footprint. As a result, these findings confirm the previous research findings from Scott (2021), that although there is evidence of countries committed to net-zero emission targets by 2050, it remains uncertain how these ambitious goals will be achieved. As a result, the Irish tourism industry cannot be considered sustainable, as it has failed to assess the carbon footprint of tourism and lacks tourism decarbonisation strategies to mitigate climate change.

From completing a comparative analysis of international studies that assessed the carbon footprint of tourism, the findings identified that there is still a need for a consistent and unified approach, as seen in Table 3. Therefore, international tourism carbon footprint data is not directly comparable across the studies because there are no similarities between the analytical approaches used; the scope of impact measured (i.e. domestic, inbound, outbound and exports); the timeframe of data assessed (i.e. a year or peak season); and units of measurement are different (i.e. CO2 only or CO2eq). Hence, yielding the researchers from establishing a baseline tourism carbon footprint figure.

Table 3. Comparative analysis of international studies assessing the carbon footprint of tourism at national and regional levels

Carbon Footprint of Tourism at a National Level							
Sourced Articles	**Destination**	**Analysis Approach**	**Scope of Impact**	**Year Data Extracted**	**Unit of Measurement**	**Total Carbon Footprint**	**Average Tourist Carbon Footprint**
Grimm et al. (2008)	**Mexico**	WWF carbon calculator	Direct	2007	CO2	7.218 kg CO2/ per trip (14 days, 2 people)	515.6 Kg CO2/ per tourist per day
Björnsson (2014)	**Iceland**	Bottom-up/ LCA	Direct	2011 (Summer only)	CO2	-	50.2 kg CO2/ per day
Sharp et al. (2016)	**Iceland**	Hybrid	Direct & indirect	2010-15 (2013 for average tourist)	CO2eq	6.4 Million tons CO2eq	1350 kg CO2eq
Perch-Niesen et al. (2010)	**Switzerland**	Hybrid	Direct	1998	CO2eq	2.29 Million tons CO2eq	-
Dwyer et al. (2010)	**Australia**	Hybrid	Direct, indirect & imports	2003-04	CO2eq	54.4 Mt CO2eq	-
Sun (2014)	**Taiwan**	Top-down/ Input–output	Direct, indirect & imports	2007	CO2eq	15 Mt CO2eq	-
Cadarso et al. (2015)	**Spain**	Top-down/ Input–output	Direct & indirect & imports	2007	CO2	63129 kt CO2	-
Farreny et al. (2011)	**Antarctica**	Bottom-up	Direct	2008-09	CO2	198,843 Tons CO2	490 Kg CO2/ per tourist
Patterson & McDonald (2004)	**New Zealand**	Hybrid	Direct & indirect	1997-98	CO2	6.8 Mt CO2	-
Becken & Patterson (2006)	**New Zealand**	Hybrid	Direct	1997-98	CO2	2689 Kt CO2	-
Kitamura et al. (2020)	**Japan**	Hybrid	Direct & indirect	2017	CO2eq	136 Mt CO2eq	-
Carbon Footprint of Tourism at Regional Level							
Grimm et al. (2008)	**Trentino, North Italy**	WWF Carbon calculator	Direct	2007	CO2	216 kg CO2/ per trip (5 days, 2 people)	43.4 Kg CO2/ per tourist per day
Grimm et al. (2008)	**Majorca, Spain**	WWF Carbon calculator	Direct	2007	CO2	1.2221 kg CO2/ per trip (14 days, 3 people)	87.2 Kg CO2/ per tourist per day
Sanyé-Mengual et al. (2014)	**Menorca, Spain**	Bottom-up/ LCA	Direct	2010-2011 (Summers only)	CO2	277 kg of CO2 per stay (20 days	14.6 Kg CO2/ per tourist per day
Rico et al. (2019)	**Barcelona, Spain**	Bottom-up/ LCA	Direct & indirect	2015	CO2eq	9.6 Mt CO2eq	96.93 Kg CO2eq/ per tourist per day
Hoque et al. (2010)	**Queensland, Australia**	Hybrid	Direct & indirect	2003-04	CO2eq	12.01-13.86 Mt CO2eq	-
Filimonau et al. (2013)	**Algarve, Portugal**	Hybrid	Direct & indirect	-	CO2eq	-	627.5 Kg CO2eq/ per tourist per day
Konan & Chan (2010)	**Hawaii, USA**	Top-down & input-output	Direct & indirect	1997 & 2005	CO2eq	5.2 Mt CO2eq	-
Hanrahan et al. (2018)	**Clare, Ireland**	Carbon calculator	Direct	2017 (Summer)	CO2eq	-	218- 333 kg CO2/ per tourist
Hanrahan et al. (2018)	**Sligo, Ireland**	Carbon calculator	Direct	2017 (Summer)	CO2eq	-	218- 333 kg CO2/ per tourist
Hanrahan et al. (2018)	**Donegal, Ireland**	Carbon calculator	Direct	2017 (Summer)	CO2eq	-	118 -229 kg CO2/ per tourist per trip

Nevertheless, the analysis identified that the internationally standardised hybrid approach and CO2eq unit of measurement are the most dominant choices amongst international tourism carbon footprint studies. However, due to the lack of consistency surrounding the timeframe of data utilised for assessments and the different scope of impact measured, these studies are still not comparable. Additionally, it was identified for the need for global Tourism Satelite Accounts, as data is available for only 70 countries. Consequently, barriers are created for

implementing a unified approach. These findings confirm the theory from previous research that was advocated by Sun (2014). Therefore, there is an urgent need for global collaboration from global tourism leaders, tourism academics, the tourism industry itself, and state governments to collectively determine the specific criteria that must be measured when assessing the carbon footprint of tourism. Thus, reducing barriers and ensuring that countries can easily compare the impact of tourism emissions at a national level.

CONCLUSION

In conclusion, it is evident that humankind is facing a climate crisis. Global greenhouse gas emissions need to be reduced drastically and immediately to mitigate climate change. The UNWTO and tourism industry leader's had a rapid response to the COVID-19 crisis, with the establishment of a Global Tourism Crisis Committee. This rapid response is also needed for the climate change crisis to decarbonise tourism and transition towards a low-carbon industry by 2050. This transition requires improving communication and knowledge distribution, increased research capacity, and strategic policy and planning engagement (Scott, 2021). The COVID-19 crisis has offered the tourism industry an opportunity to explore and frame the new, post COVID-19 sustainable strategies for responsible tourism recovery plans. Furthermore, it provides an opportunity for countries to prioritise measuring and reporting tourism emissions, to enable state governments to compare their carbon footprint data internationally.

This study intended to enhance the understanding of the importance of measuring and reporting tourism emissions at a national level. Whilst investigating the benefits and limitations of the different analytical approaches and toolkits previously used to measure the carbon footprint of tourism. Tourism is a significant contributor to greenhouse gas emissions, and it will continue to grow post-COVID-19. Like all industries, the tourism industry is expected to decarbonise to achieve emission reduction targets. Furthermore, all industries need to analyse emissions in as much detail as possible. Policymakers and destination managers need this detailed research information to ensure efficient resource allocation occurs and that appropriate mitigation and adaptation strategies are implemented. Hence, Ireland needs to assess the tourism industry's carbon footprint to determine the progress being made to improve the environmental performances of tourism. Additionally, this establishes whether Irish tourism is transitioning towards a low-carbon industry.

Ireland has failed to meet the greenhouse gas emission reduction targets for the last four consecutive years. The state also has the third-highest emissions in the European Union (13.3

tonnes of CO2eq per capita) (CSO, 2019). In 2019, the Irish Government launched the first Climate Action Plan to drastically reduce emissions and transition towards a low-carbon economy by 2050. However, from completing a quantitative content analysis, this study identified that the carbon footprint of tourism has not yet been assessed and lacks serious decarbonisation discussion within all national plans. Thus, Ireland is failing to seize the opportunity to restart tourism in a sustainable approach, as tourism cannot be considered sustainable unless it is decarbonising to combat climate change.

Moreover, the findings from a comparative analysis of international tourism studies established the need for a unified approach to measure the carbon footprint of tourism. Furthermore, it was established that globally there is a need for greater interdisciplinary collaboration to collectively determine the specific criteria that must be measured when assessing tourism emissions. Thus, reducing the barriers of comparing international tourism emissions data. This is due to the previous international studies not being transparent and comparable and could not be utilised to form a baseline carbon footprint for tourism. However, it was identified that the hybrid approach is the dominant approach utilised to measure tourism emissions, as it overcomes the limitations of using only one approach. Unfortunately, Ireland is unable to assess the carbon footprint of tourism by using the top-down approach or a hybrid approach due to the lack of economic data. Additionally, Ireland, like many other countries, does not have the Tourism Satelite Accounts data yet. Consequently, only the bottom-up approach or the recommended carbon calculator can be utilised to measure the carbon footprint of Irish tourism.

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The Design Journey of a Collaborative Community based Self-Expanding (CCSE) E-Learning Model: A Practical View

Shalini Anita Chellaraj and Dr. Fiona Carroll

Abstract

Covid -19 has resulted in school closure all around the globe and over 1.2 billion learners are out of the classroom as a result, learning and teaching have become more reliant on digital platforms. However, not all teachers and/ or learners have expertise in digital technologies and may not have access to the right equipment. The COVID-19 pandemic has exposed this digital divide but at the same time, it has also made online education the mainstream (Jaeger & Blaabaek, 2020). And as a result, there is a need for an eLearning environment that fosters inclusivity, socializing abilities, interaction, contributions, peer support, and motivation. This paper focuses on the design and development of a Collaborative Community based Self-Expanding (CCSE) learning Model, which will be used to develop a scalable online learning community. The uniqueness of this model is that it will bring diverse learners together and give them the flexibility to choose their preferred method of learning, based on their level of knowledge, skills, and interests to obtain the desired outcome. This paper highlights the need for collaboration and community-based learning; it highlights the design and initial implementation phases of the proposed CCSE learning model and its community-based learning network principles. It is envisioned that a community spirit fostered by the system will add great value to the future of learning during and after the COVID -19 pandemic.

Introduction

Covid -19 on the positive side, has resulted in learners and teachers being more adaptable to technology. Commuting journey times to learning institutes, etc, are reduced by learning from

home. This is very attractive to many learners and may even drive the education market post-pandemic into a home learning culture and students will not always need to come to school physically (Hidayatullah and Saud, 2021). However, not all learners and teachers have the skills and knowledge, and equipment for using/ engaging with digital technologies. Hence, advanced technology and investment in online learning to enable effective learning is in huge demand now. Many education providers have become interested in how to best deliver online courses, engage learners and conduct assessments. COVID-19 whilst being a threat to the economy of many countries has evolved organizations to invest in online education.

As we have experienced, social distancing is necessary to reduce the spread of COVID-19, but it can also make us feel lonely and isolated which can increase stress and anxiety (Panchal, Kamal, and Garfield, 2021). The pandemic and the lockdowns have affected the mental health of people around the globe (Cao *et al*., 2020; CDC, 2021). Therefore, an eLearning environment that nurtures social interaction, peer support, and motivation is more important than ever. Although learners consider online learning as having viable options there is huge scope for improvements (Chakraborty *et al*., 2020). Learners should be given more autonomy to construct resources and their participation should be recognised. Indeed, the authors of this paper feel that a community-based learning support culture should be promoted to enhance the online learning experience and counter isolation and loneliness.

In this paper, we discuss the design and development of a dynamic Collaborative Community-based Self-Expanding (CCSE) learning model enriched with flexible resources and at its core collaboration, knowledge sharing, and a peer support culture. It is envisioned that this model will provide a self-expanding learning environment that is developed by the learners themselves and has the potential to foster engagement, social interactivity, and reflexion. In

doing so, the aim is to identify the priorities for establishing a practical and worthwhile eLearning model addressing the needs of the 21st century.

Blended Learning and Web 5.0

The evolution of social media channels like YouTube, Facebook, WhatsApp, Instagram, etc has rapidly grown the community learning and teaching network. The availability of flexible learning resources video, online content, books, journals, and so on has, in turn, led to the increased use of flexible delivery methods. This has raised questions about the effectiveness of these methods, the quality of interaction between the learners, and learner satisfaction. Biasutti (2011) states that learner satisfaction in an e-learning environment increases with collaboration, knowledge sharing, and peer support. Sethi *et.al*. (2019) states more students cantered learning approaches are evolving and students are encouraged to construct knowledge actively. Some research confirms that the retention rate of eLearning is 25-60% and face-to-face is only 8-10% (Gutierrez, 2016). The time required to learn online is 40-60% less than learning in a traditional classroom setting (Li and Lalani, 2020). Despite these benefits, the human values of socializing are missing greatly and driving the growth of the depression rate (Offord, 2020).

We now have 'a sensory emotive Web (Web 5.0) and, more than ever before, there will be a deep need for teachers to use and promote intra and interpersonal emotional competencies' (Benito-Osorio, 2013). For many, a blended learning environment is an answer, which allows the learners to place their constructs with the other resources within the system to be shared with their peers; it allows us to maximize many positive education functions (Dziuban et al., 2018). Students themselves set an agenda for learning and collaborate in a blended learning environment by realizing the importance of feedback. Likewise, the teacher's role is also inevitable. Learners in online blended learning environments take learning roles that are

different from those in a traditional face-to-face classroom. Eventually, these learners developed autonomous perceptions and behaviours as an outcome of their engagement (Navaporn, 2013). Moreover, eLearning platforms enabling collaboration can be used to showcase ability among peers. Many contributors may openly share knowledge because they consider their connections with peers and networking as the lifeline to their professional and business development (Wijk, 2010). Collaborative activities empower the learners to become active learners (Anderson and Simpson, 2004) and high-quality online courses are delivered through collaboration (Chao *et al*., 2010). Learners who perceived high levels of collaborative learning tended to be more satisfied with their distance course than those who perceived low levels (Hornik and Salas, 2008). In the pre-COVID culture, socialising was possible face to face. However, at present, there is so much emphasis placed on social distancing which advances the need to collaborate at least online to build a peer support culture.

Collaboration, Interaction, and Social presence

For many years, collaborative learning theories focused on the individual's function in a group. Interestingly, researchers have recently started to understand the role that variables such as nature of the task, communication media size, and composition of the group play in mediating interaction (Stahl, G. et al., 2006). This new dimension requires advancement in tools for analysing and modelling interactions. Effects of gender, competence might differ independently based on domain, age, with the teacher, and so on which in turn requires methodologies for understanding, analysing, and interpreting group collaborations (Stahl, G. *et al*., 2006).

Many eLearning systems like Blackboard and Moodle are quite popular recently however, they have not been fully utilized to collaborate (Carvalho *et. al*., 2021). The vast majority of

Blackboard learners (72.4%) and 60.4% of Moodle learners have never engaged in 'participating in forum discussions and over 86.7% have never participated in course chatroom (Carvalho *et al*., 2021). Interestingly, a recent study (Appavoo *et.al*., 2021) disclosed that nearly half of the learners were not making regular use of Moodle in their studies.

Many faculties use alternative social media systems like google groups, or yahoo groups although VLEs (Virtual Learning Environments) like Blackboard are also available to them (Carvalho *et al*., 2021). Perhaps, they are not satisfied using rigid VLE platforms and find collaboration easier in other social media sites? The LMS systems widely used nowadays do not seem to have mastered the true benefits of social media (Tasneem *et.al*, 2017). These gaps have led to a huge pool of research opportunities around e-Learning (Stahl, G. *et al*., 2006). As Kop *et al*. (2008) highlighted we need to 'move away from using a VLE primarily as space which holds content and re-envisage it as a community; to create a place where dialogue can take place and all interactions and content can be easily seen, accessed, followed.

Social presence in the other words the feeling of being there with a "real" person, is a fundamental component of interactions (Catherine *et.al*, 2018). Interestingly, social presence itself is a factor contributing to learners' success (Johnson *et al*., 2008). The learners' feeling of being part of a learning community and the social aspect promotes their learning (Hudson *et al*., 2006). The quality of interaction affects the learning outcomes (Shafipour, et. al, 2017) Learning in Higher Education particularly arises from interacting with teachers and peers rather than the content (Dalziel &James, 2003). There is a general concern that e-learning is seen more as providing teaching material and less as improving interactivity. Zhang *et al*. (2006) state interaction is the main enabler for learner retention, performance, and satisfaction.

Effective e-learning environments should consider dialogical and social interactions between participants, rather than just information and knowledge transmission (Tsangaridou, 2012).

Utilitarian, Hedonic IT and Reflexivity

In the majority of experiments learning outcomes have been improved by the use of technology (Lehtinen *et al*.,2010). The same collaborative activities could be carried out without computers to achieve similar positive results. Therefore, technology-based instructional innovations in practical classroom situations need to be analysed and evaluated more carefully against the use of collaboration in the classroom using other non-technological strategies. The future of E-learning should be eventually designed with all the technological advancements in mind (Lehtinen *et al*.,2010), facilitating a wide variety of resources (audio, video, ESR, ISR) and utilizing the most up-to-date Artificial intelligence technology. Kahiigi *et al*. (2008) endorse that addressing emerging issues around identifying new pedagogies and changing teaching approaches to include technologies is paramount.

Utilitarian IT uses technologies like eLearning systems, word processing software, etc to promote academic learning. Abrams & Walsh (2014) state that, future research can investigate how educators can leverage adolescents' interest by developing educational systems that include more hedonic features such as gamification, social media, and videogames (Turel 2016; Turel, He, Xue, Xiao, & Bechara, 2014; Turel *et al*., 2015; Turel *et al*., 2016). Furthermore, recent studies have pointed to the potentially addictive characteristics of hedonic IT, including social media (e.g., Vernon, Barber, & Modecki, 2015) and videogames (e.g., Festl, Scharkow, & Quandt, 2013).

Through reflexivity, learners can exercise control over their cognitive activity and actions, which allows self-assessment and constructive criticism on themselves (Mahony et .al, 2007). Individual and collective reflexivity is used to build group awareness, and synchronous collaboration among participants (Farooq *et al*., 2007). Displaying the history of the learner's activity is an effective way to encourage learners' reflection on their learning process, results achieved and knowledge obtained. By this means, the learner can ensure/ judge the relevance of his/her approach or readjust his/her actions. Individuals are capable of evaluating their behaviour (i.e., self-evaluation, self-reflectiveness) through observation of that behaviour and the associated outcomes (i.e., self-observation). Based on this evaluation, the behaviour is (dis)continued or altered (i.e. self-reactiveness). This evaluation of behaviour occurs based on goal setting which refers to objectives one wishes to attain by performing a certain behaviour. Hence, the outcomes one desires to attain through a particular behaviour serve as a benchmark against judging effectiveness (Bandura, 2001).

Distributing leadership and constructivism to building peer support

The distributed leadership approach focuses on creating great immediate outcomes with little management in place by distributing the leadership. Goffee & Jones (2007) state that platforms linking the professionals directly to their commitment, their development, and values will thrive. The implicit core values of this organizing model are trust, relationships, transparency, collaboration, and continuous learning. These intangible pillars of the platform rely not on locking-in clever people through formal contracts and performance measurement tools, but rather locking-on people through a deeper sense of commitment, reciprocity, and shared purpose. Flawless teamwork is required in the delivery of such a program. The platform members are involved in various networks with different procedures and require an extra effort to build a relationship and adhere to these processes.

Cordingley's paper highlights making use of specialist expertise and structured peer support for embedding specialist contributions and commitment to professional learning (2015). A study by Cordingley *et al*., (2005a, 2007); Robinson *et al*., (2009); Timperley *et al*., (2007) involves specialists actively seeking out peer support and taking opportunities to build professional learning.

In addition, constructivist learning applications underpin learners to do something, instead of just learning. In constructivism, learning theories used are cooperative learning, problem-based learning, and project-based learning. The essential core of constructivism is that learners actively construct their knowledge and meaning from their experiences and environments individually (Rahman *et al*.,2008). Constructivist learning applications promote a rich and interactive learning environment. A student is required to obtain knowledge, analyse it, arrange and use it to solve the problems by the way of cooperative learning activities. In the learning process, the student is expected to produce his/her product by searching, decision making, collaborating, using thinking skills, and creativeness. The constructivist approach accepts that the learner constructs the knowledge both individually and socially (Ozden, 2005). In addition, Rahman, et .al, (2012) findings indicate that knowledge developed via experiential activities is of the greatest importance for the learners. Constructivist theories suggest that the learners were not relying on only one or two sources of information but making use of any sources that were available to them. Hence, it is crucial to understand which sources help different learners grow particularly in line with a constructive learning environment

Phases Of Design of CCSE eLearning System

The following describes the design phases of the CCSE eLearning system, that addresses the need of learners to collaborate, build a peer support culture, and progress. The phases discuss how the model (CCSE) was formed from the theoretical framework studied. The design phases of the eLearning online system based on the model involve identifying user and usage context, specifying requirements, and designing the system using wireframe (Visio). The fully functional eLearning system will be developed using C#, SQL Server, JavaScript, and Ajax and hosted in the Microsoft Azure cloud computing environment. It will be accessible to all learners online. A highly responsive Bootstrap theme will be used to ensure compatibility, consistency, and responsiveness.

Once the eLearning system is hosted detailed quantitative and qualitative studies based on the usability of the system and the hypotheses to be tested will be conducted and findings discussed and analysed. Data collected from the Microsoft Azure Application Insights, database, logs, and participatory observations will also be studied more in detail. Further research will be undertaken involving diverse user settings. The aim is to establish a benchmark for community-based learning standards.

Phase 1: Identify users and usage context

The user-centered design (UCD) approach (see Figure 1) is used to design the CCSE system to ensure that it is extremely accessible and acceptable for the end-users. The user-friendly design will also ensure security and privacy.

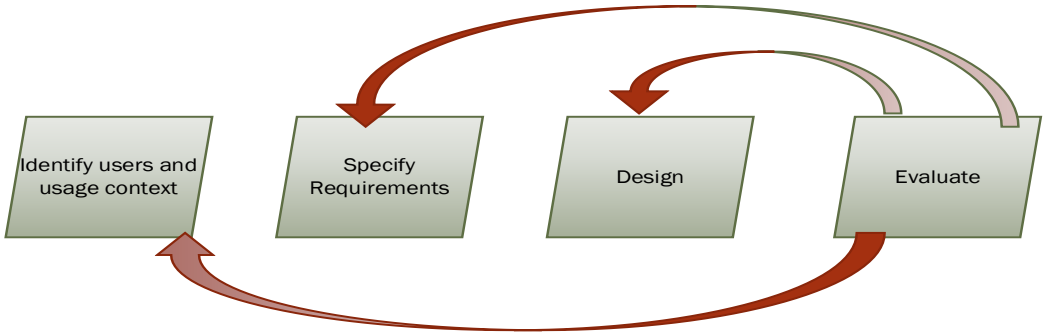


Figure 1 User-cantered Design

As the first step users were identified and the contexts were analysed based on answering four main questions What are the users' tasks? Which tools can support users' goals? Where will the system be used? Are there any technical constraints? The main users identified were Learners, Subject experts, Learner advocate, and Admin. Each target group's tasks and goals were also defined via a use case diagram (see Figure 2).

The use case diagram describes the functions and overall scope of the system. Interactions between the system and actors and how the actors users the system. The Use case diagram also formed the foundation of the Entity-Relationship Model of the system. A rough sketch of ER model was drawn on paper and then automatically generated from the SQL server database from the tables and the relationships between them.

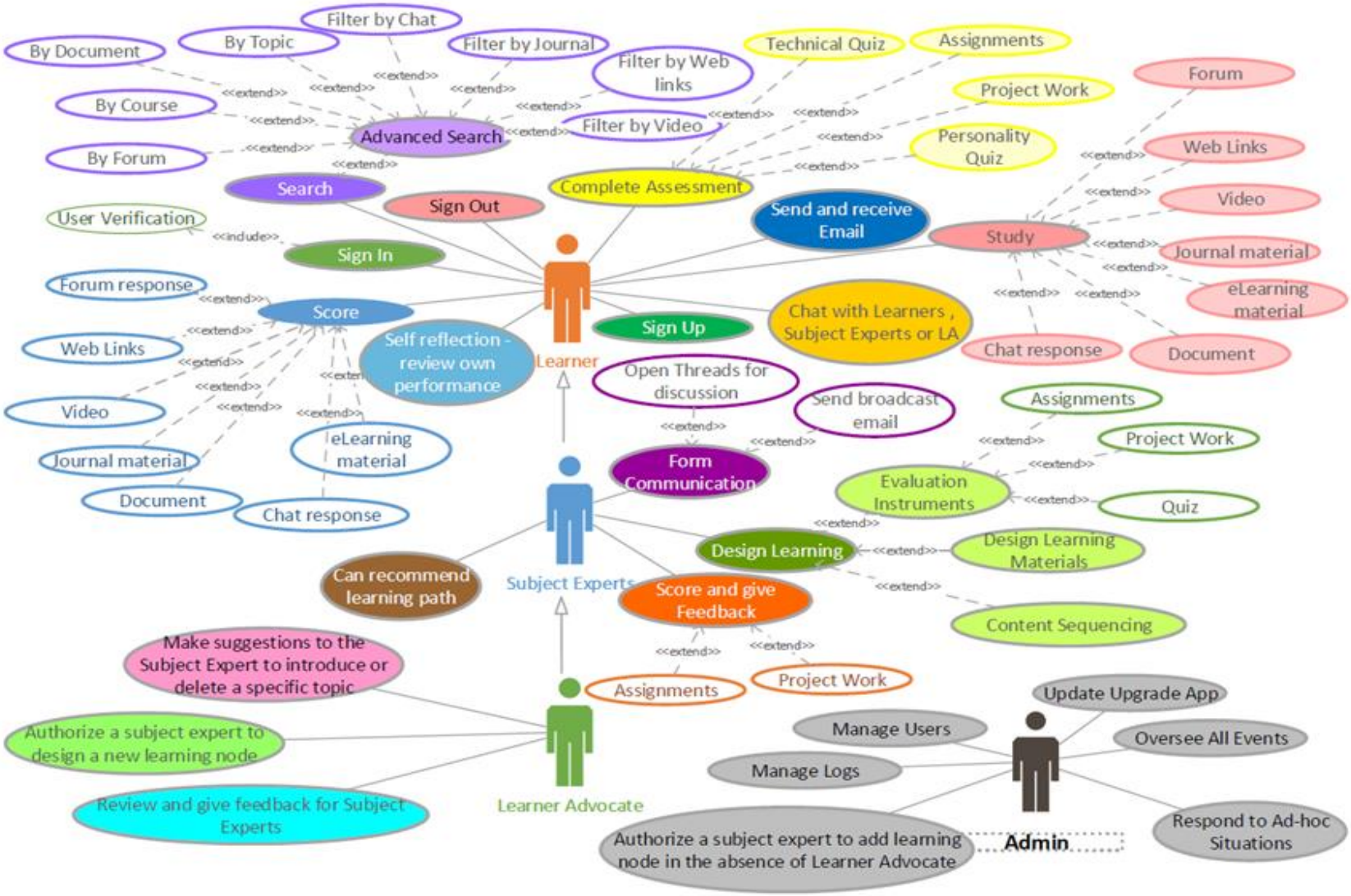


Figure 2: Use Case Diagram for CCSE eLearning Model

A learner can be nominated as Learner Advocate (LA) by the admin or they could gain points based on their knowledge, performance, interaction, collaboration, and achieve the LA status. Therefore, any outperforming learner has the potential to become Learner Advocates and earn more pedagogical responsibilities (see figure 3).

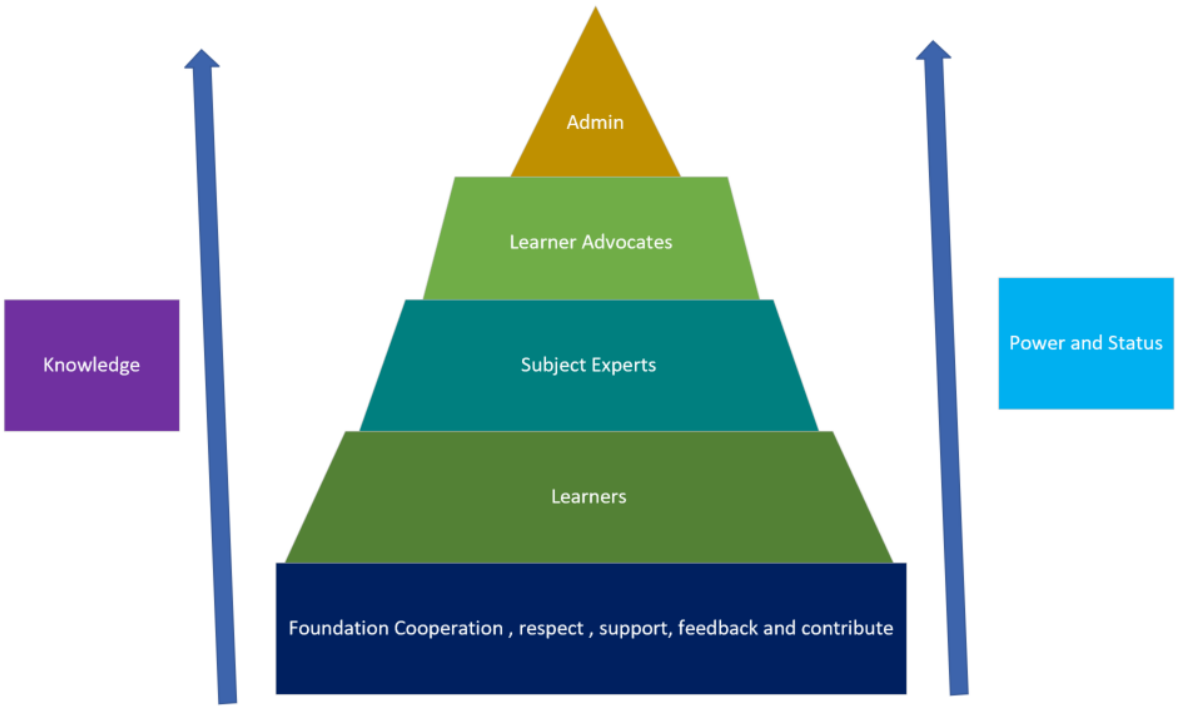


Figure 3: Hierarchy of the users of the CCSE E-Learning model

Such distributed leadership principles are the foundation to build a peer support, collaborative environment. Quality of participation will be accessed via review score, rating, evaluations, and likes. The Learner Advocate (LA) status is identified within the system to "locking on" people through a deeper sense of commitment, reciprocity, and shared purpose as suggested by Goffee and Jones (2007).

The community-based principles of the system originate from the community-based caste system in West Africa where hierarchy is based on caste. People changed occupations or

acquired secondary specializations and moved up or down in status or rank (Tamari, 2009). The hierarchy of the learning community fostered by the system proposed in this paper will not gain power based on caste or job, in contrast, it will be based on purely Knowledge. Some learners gain more influence and become superior because of their wisdom and ability to share and support others in the community. As a foundation, to maintain a peaceful relationship, each member is obliged to acknowledge and respect the other members.

Phase 2: Specify requirements

Concept mapping was prepared to understand the CCSE eLearning model requirements and group them according to their priority (see figure 4). This categorization is an essential process because the system will not work if the functional requirements are not met (Burak, 2021). This grouping also aids in prioritization. Making the content available in multiple media formats will address the needs of learners who adopt different methodologies to learn. Forums, Blogs, and Weblinks upload are essential features to allow the community of learners to construct new knowledge. Assessment and feedback are needed to motivate each other in the group therefore, all these tasks were considered as the foremost priority to build the system. Other mandatory functionalities required are the ability to login, logout, register, and user management. The functions which were considered as not required were ignored in the system design phase.

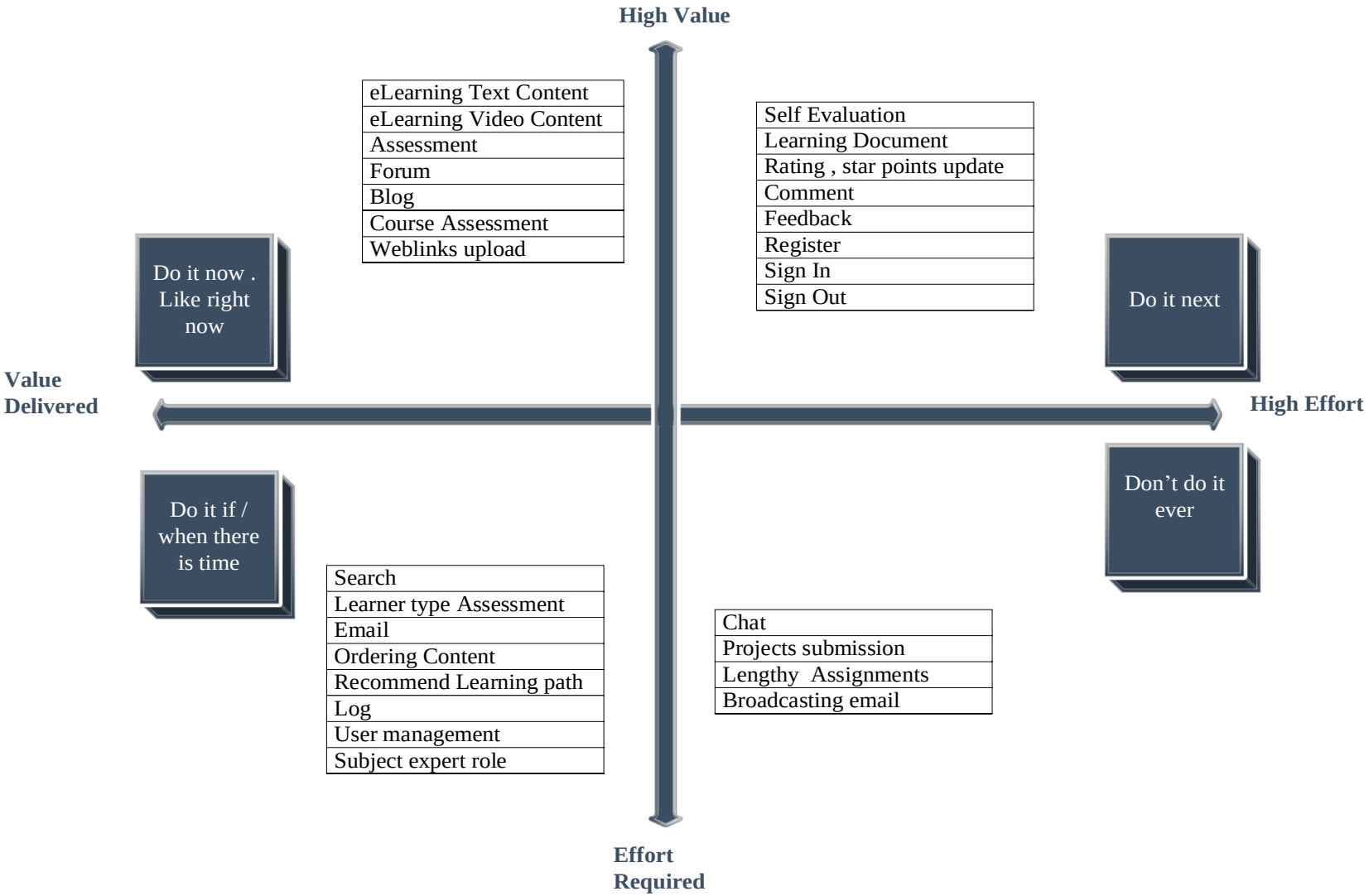


Figure 4 Concept Map for CCSE system requirements prioritization

The system requirements were then further refined using user stories (see table 1 for an example of a CCSE user story.

CCSE user story description:
As a User, I should be able to register to access the system.
Conditions of Satisfaction:
• A user can register to create an account and access the system • The user should be able to enter login details and sign in • The user should be able to sign out • The user should be able to change his / her registered details

Table 1: An example of a CCSE user story

Phase 3: Design

The set of requirements gathered outlined the architectural functional design of the CCSE model-based eLearning system. Rough sketches of the system layout were initially drawn on paper, before designing in Microsoft Visio. The design process incorporated iterative approaches, accommodated changes, ensured quality, and minimized conceptual errors. An overall system architectural Design can be seen in Figure 5. To establish the learning network of the model, the authors have adapted the Cooperative Neural-Network Ensembles (CNNEs) algorithm using incremental training (March & Steadman 1971 and Islam *et al.* 2003). During the incremental training of the dataset, a component network was built by adding new nodes. Similarly, the CCSE eLearning model learning network will be built by adding new nodes based on Network or graph theory. The output of the ensemble is the average of all component outputs scores. The packing of basic units in a hexagonal structure (see Figure 6) is the geometrical basis of the central place theory (Christaller, 1933 &1966).

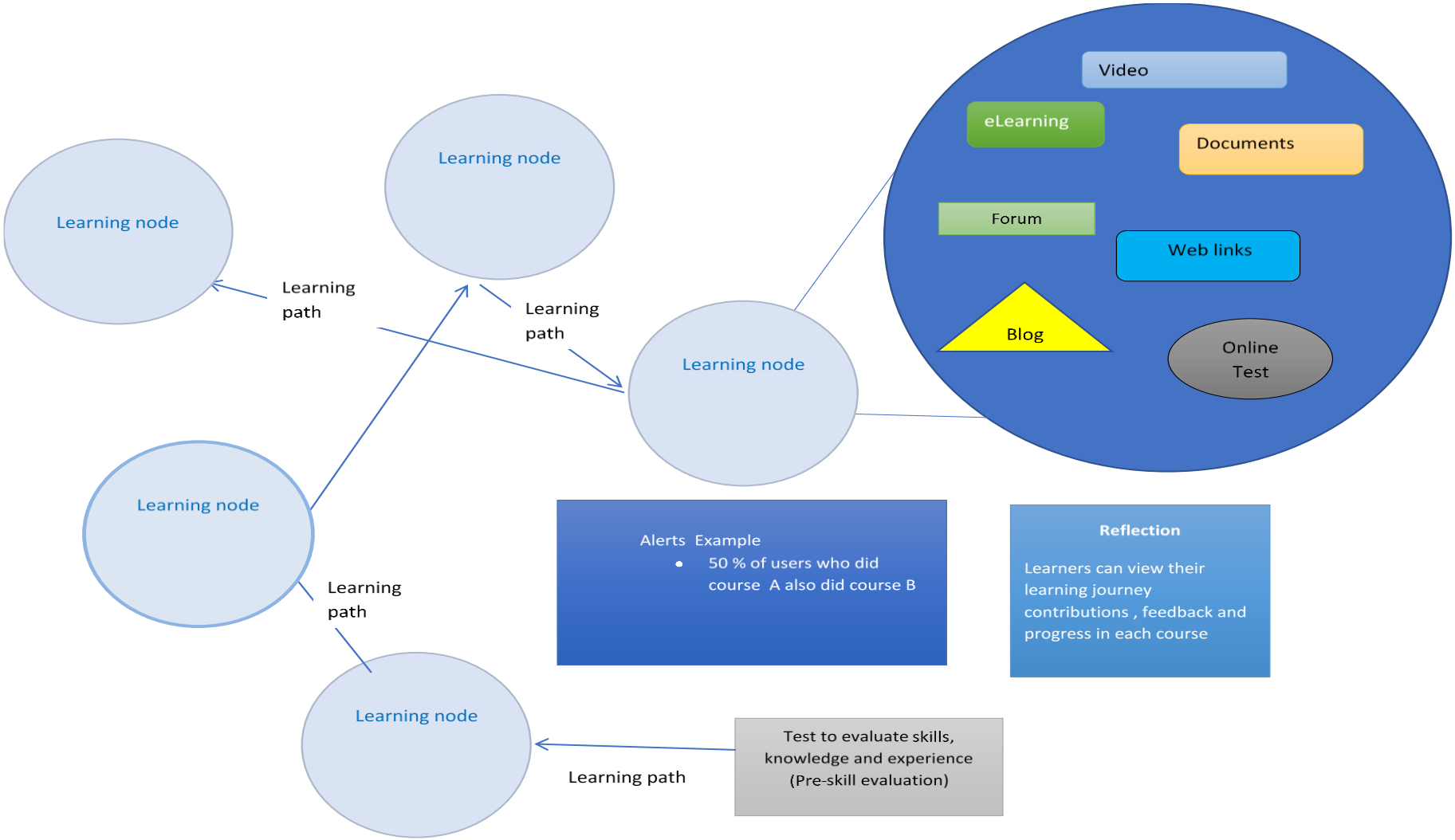


Figure 5: Overall System Architecture

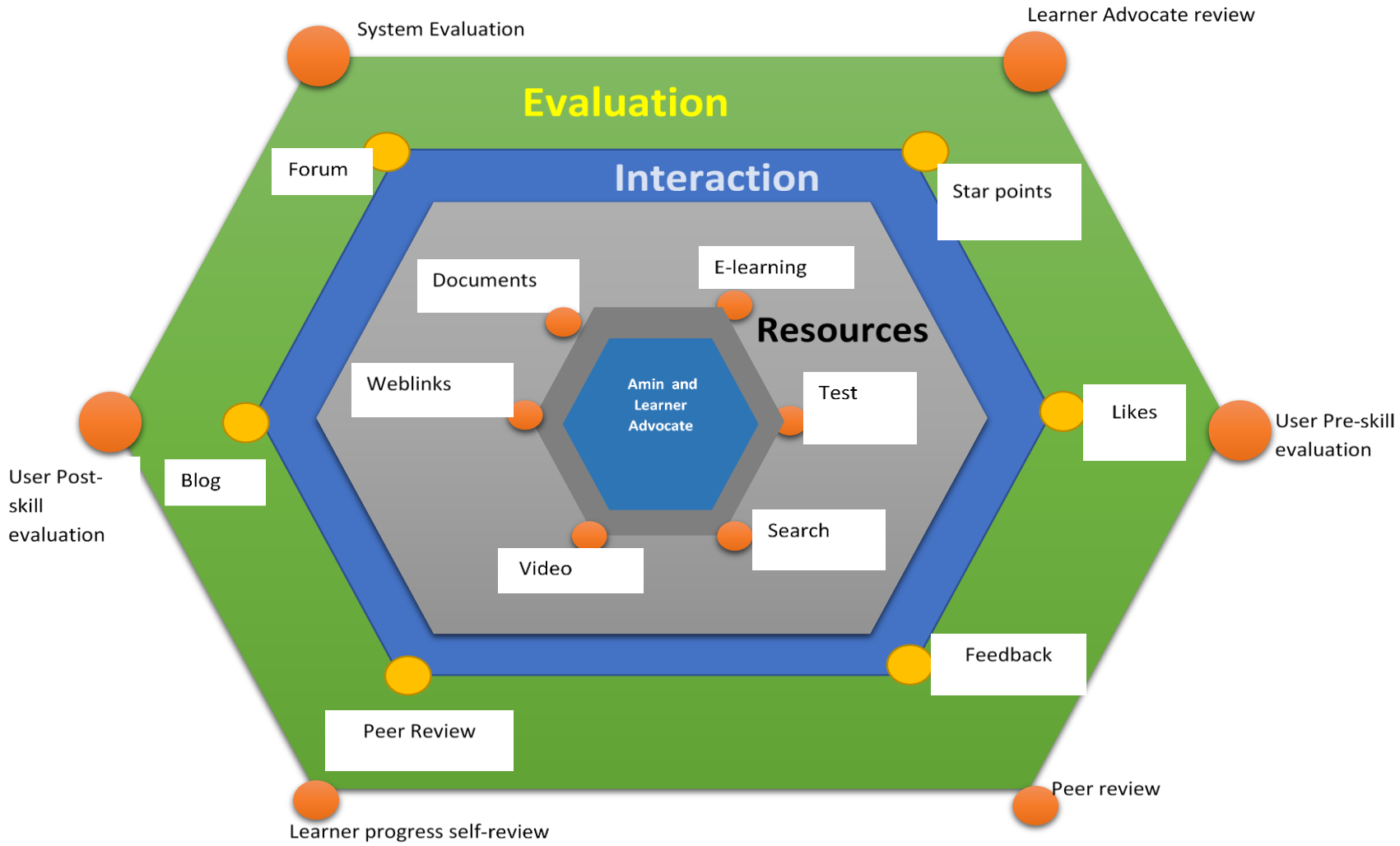
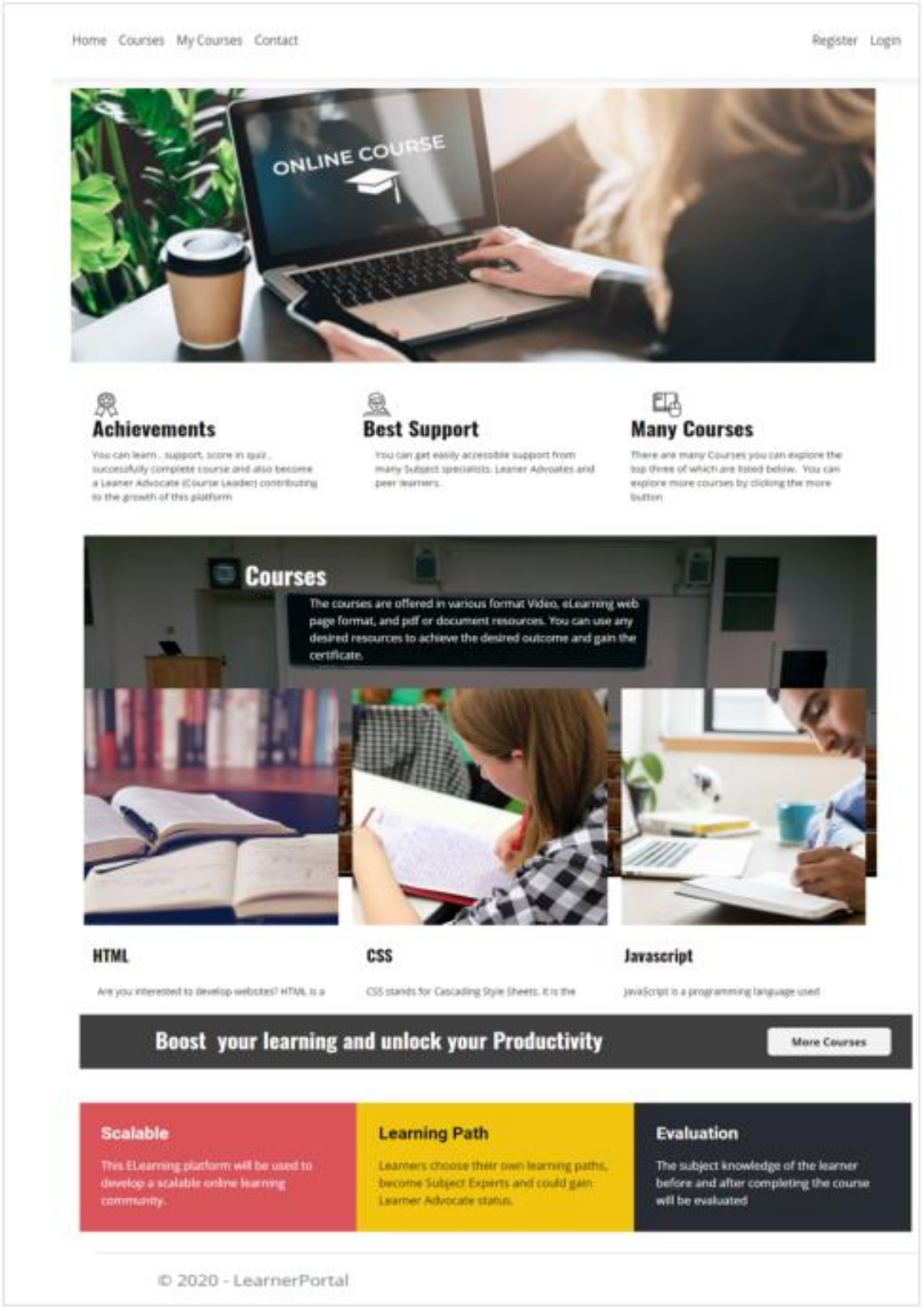


Figure 6: Detailed System Architecture of each bubble / Learning node

To summarise, each of the circular connecting learning nodes in Figure 5 has the sub-components evaluation, interaction, and resources as shown in the hexagonal structure (Figure 6). The learning node will be added to the system dynamically and connected via learning paths. An emphasis will be placed on perceived ease of system use and usefulness because they are known to be valid predictors of attitudes toward system use and user satisfaction (Davis 1989, DeLone *et.al*, 2003 and DeLone et. al. 1992).

Based on the above two architectural diagrams the web pages of the eLearning system were sketched using Visio. The home page Figure 7 is kept simple with a brief introduction and a basic navigation structure to the key areas of the system. The designs will be further revised based on the re-evaluation and user testing.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ONLINE COURSE
Achievements
You can learn , support, score in quiz , successfully complete course and also become a Learner Advocate (Course Leader) contributing to the growth of this platform
Best Support
You can get easily accessible support from many Subject specialists, Learner Advocates and peer learners.
Many Courses
There are many Courses you can explore the top three of which are listed below. You can explore more courses by clicking the more button
Courses
The courses are offered in various format Video, eLearning web page format, and pdf or document resources. You can use any desired resources to achieve the desired outcome and gain the certificate.
HTML
Are you interested to develop websites? HTML is a
CSS
CSS stands for Cascading Style Sheets. It is the
Javascript
JavaScript is a programming language used
Boost your learning and unlock your Productivity
More Courses
Scalable
This ELearning platform will be used to develop a scalable online learning community.
Learning Path
Learners choose their own learning paths, become Subject Experts and could gain Learner Advocate status.
Evaluation
The subject knowledge of the learner before and after completing the course will be evaluated
© 2020 - LearnerPortal

Figure 7: Draft Home Page of CCSE eLearning Model

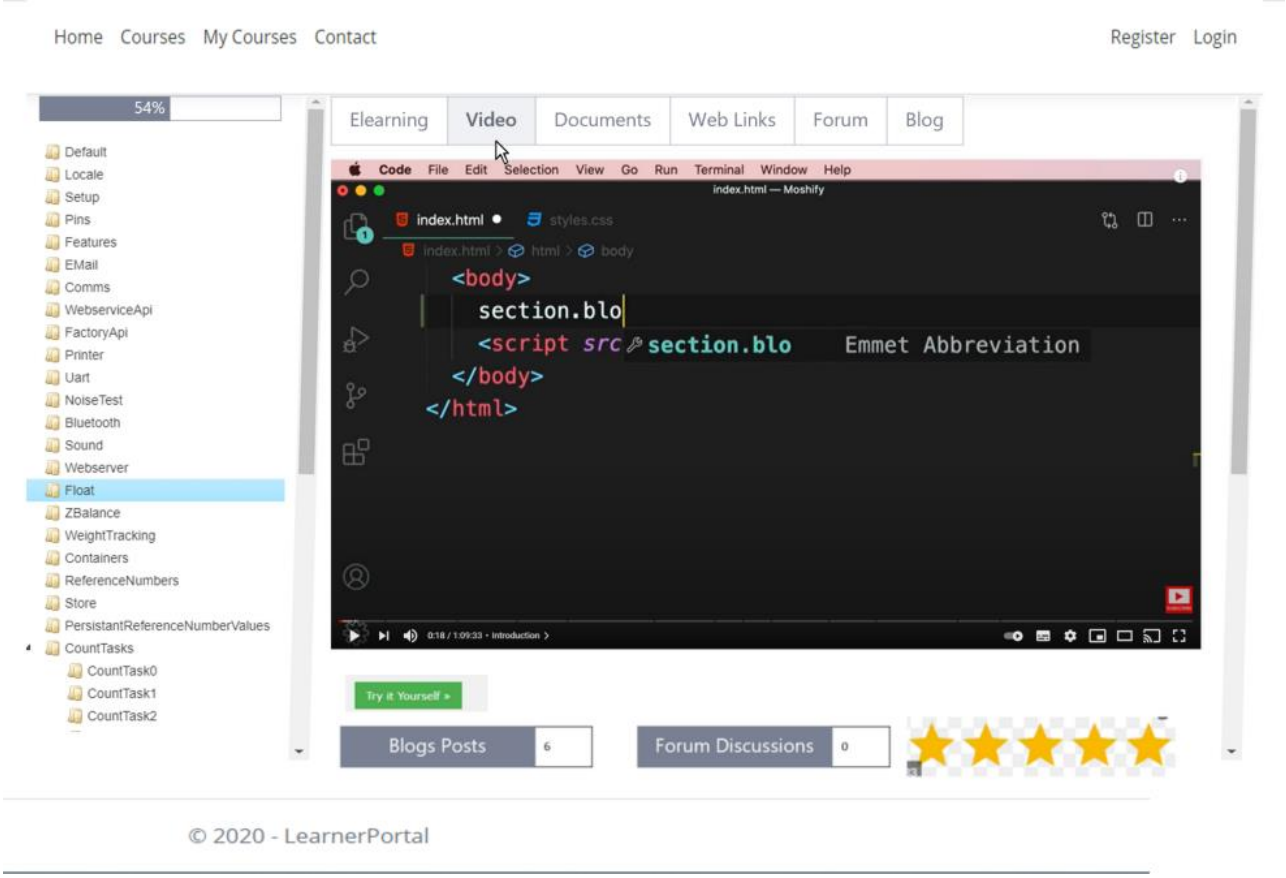

Figure 8: Course Content Page of CCCSE eLearning Model

The course content page is simple and easy to navigate. The status bar shows the progress of the learner in the course. jsTree is used to display the topic's name on the left-hand side. When each topic is clicked the detailed content (eLearning, Video, Documents, Web Links, Forum, and Blogs) appears on the right-hand side. Each course topic is linked to the relevant Blog and Forum post so learners can learn from peers and also contribute to constructing new knowledge. The course contents can be reviewed and rated by the readers/learners. Learners can contribute to Web Links, Forum, and Blog sections, and become subject expert once he/ she scores enough points required

for a subject/course. Learner Advocates can create a new course and update the eLearning, Video, and Documents content as well.

Phase 4: Evaluation

When the initial working CCSE prototype is complete, it will be evaluated based on 'Moderated User Testing' and 'Remote Moderated User Testing' approaches (User Experience Researchers, 2021). In moderated user testing, the moderator will sit beside the user and gain deep insight into the users' perception of the system by questioning while simply allowing the users to navigate and use the system. During remote moderated user testing, the moderator will use zoom screen sharing and webcam features to view the actions of the user and simultaneously ask inciting questions to evaluate the user experiences. It is envisioned that the results of this evaluation phase will provide opportunities for further improvements to the design of the CCSE system to ensure that the final working product will afford community-based learning as well as provide a user-friendly learning experience.

CCSE model address four distinctive challenges (1) Enabling collaboration and a peer support culture (2) Giving the learners the ability to progress as a subject expert and thereafter gain Leaner Advocate status (3) Facilitating an expanding learning network empowered by the learners (4) Creating an environment where learners can reflect on their journey. The CCSE system will facilitate ***collaboration*** by providing the learners with the facility to comment, rate, review, and contribute to blogs and forums. Learners who perform extremely well will be ***promoted*** as Learner Advocates. The learning network will be ***grown*** by allowing all users to contribute. The quality

of constructs will be rated by ***peers and self-evaluation*** is an option too. Finally, the CCSE system should be designed to translate fragmented existing information into clearly structured information regarding learner journey, completed courses, score obtained, star rating obtained resources posted, and so on.

Discussion

Innovations in e-learning require a revolution in education, allowing adaptive blended learning, enhancing interactive collaborative learning, improving access to a variety of quality educational materials, and transferring the teacher's day-to-day roles to learners (Ruiz *et al*., 2006). Numerous research opportunities exist in evaluating the impact of e-learning on the efficiency and quality of education. Potential areas for research include assessing the use of e-learning in the higher education context, the differential use of e-learning in technology-based and non-technical students community, the adaptation of e-learning to a wide variety of cultural settings, an exploration of methodology to simplifying e-learning process to gain wider use and acceptance, incorporation of e-learning as a portion of a blended-learning strategy, and the use of peer interaction and multimedia instructional resources to improve outcomes. A mature approach to framing a sequence of multi-learner activities is a blind spot in e-learning today.

The eLearning system proposed (CCSE Model) effectively combines the benefits of Blended learning, collaboration, social presence interaction, the use of advanced technologies, Utilitarian and Hedonic IT to facilitate an environment in which learners can take shared distributed leadership responsibilities support peers, engage and reflect on their behaviours. Moodle and

Blackboard platforms are driven by tutors and therefore, learner power is limited. In contrast, the CCSE eLearning model is believed to put learners in the driver's seat. Pedagogical principles feedback and positive comments are essential to foster Learner motivation, and meaningful assessment is endorsed in this study.

During the design stages of the eLearning system based on the CCSE eLearning Model, the wireframe was modified based on a user-centered design approach. The users and user actions were drafted in a rough sketch which was iterated several times and revised before the actual use case diagram was drawn using Visio. The concept mapping exercise helped to focus on the priorities which were essential for testing the hypothesis of this paper. Essay-type assignments, broadcast email, and chat facilities were considered disruptive rather than being helpful and removed from the system design. Essay-type questions are time-consuming for the volunteering Learning advocate to assess. Broadcast email functionality if enabled may result in many unread junk emails bombarded in learners' inboxes and demotivate them from using the system. Chat functionality may be distracting too when learners focus on learning in their own free time. Several user stories became the foundation for the development of the micro functionalities of the system. The wireframe build using Visio was very useful for building the initial design of the web pages. The design was revised based on review meetings with subject experts. Initially, Course specific Blogs and Forums were drafted in the design however, later this scope was changed to be topic-specific forums and blogs. Reusability of code and having a responsive bootstrap theme compatible with any screen size were considered mandatory requirements of the design.

For the development of the eLearning system, the Dot Net core C# web application is embraced. SQL Server code first approach is used so any new fields or tables could be added to the database easily. 'Nicepage' and bootstrap themes were customized to design some of the UI screens rapidly. Full Zoom integration was developed with the web application however, it was later acknowledged that the learners are expected to engage and construct dynamic learning content at their own pace therefore, there is no necessity for an online session via zoom. Therefore, the zoom integration code was removed. Cofoundry content management system was integrated initially with the application to manage content however, due to technical barriers it was not possible to have the same login for Cofoundry and the eLearning system. Therefore, a bespoke content management system was built using Summernote and C #. The 'like', 'comment', 'respond' sections that enable interactions are built in the system using C#. Jquery and Javascript. With all these initial developments there is still a long way to go before making the system fully functional and ready for testing.

Conclusion

Online learning is increasingly becoming part of the education system worldwide more rapidly since the origination of COVID -19. However, there is still room for improvements to maximize the benefits gathered from using the communication and collaboration tools of the online learning platform (Carvalho, Areal, and Silva, 2021). Education providers are investing more time and resources in improving the online learning experiences for the learners at present. In 2005-6, E-Learning was seen as a new paradigm for education and training (Mikic and Anido, 2006; Khan, 2005) and has fostered a wealth of new prospects for the future of education (O'Neill, Singh & O'Donoghue, 2004).

It is proposed that the Collaborative Community based Self-Expanding E-Learning Model (based on distributed leadership principle fostering collaboration, interaction, socialization, peer support, use of technology, and evaluation) presented in this paper has the potential to create a scalable and engaging online learning community. What makes this research especially relevant and unique is that it can create a self-expanding eLearning model not limited to the knowledge of the tutor with enhanced collaboration and peer support culture. This paper highlights the theoretical framework and proposes CCSE eLearning platform architecture and designs. The wireframe of the system is developed using Microsoft *Visio* which ensures the system is easy to navigate and includes the core principles of the CCSE eLearning model. The application is currently in development using .net Core, C#, SQL Server, JavaScript and jQuery, CSS, and Bootstrap.

Moving forward, it is planned that a selected list of learners from various diverse backgrounds and countries will participate in the user testing of the CCSE system. The focus will be on how the CCSE eLearning model develops engaging learning communities which can then contribute new resources, provide effective peer support and feedback. In doing so, the goal is to create new knowledge around the field of technology-enhanced learning environments, benefiting learning communities, university decision-makers, academic advisors, faculty, learners, and new business. This research is indispensable, mainly because the more insight decision-makers have about the learning styles and perceptions of eLearning, the greater likelihood that the demands of the learners will be met enhancing the quality of the educational experience.

During COVID-19, we witnessed the rise of online education and we are now at a stage where we need to ensure that learners can experience their optimal online learning experience. One of the intended results of this research is to propose new ways to extend the abilities of the learners to generate new knowledge, improve engagement and enhance peer support among learners. This is specifically important when people are isolated in their homes due to the pandemic. The aim is to motivate learners and teachers with a community-based learning experience fostered by the CCSE system and in doing so to add value to the future of learning during and post a COVID -19 pandemic.

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Valuable insights into the aesthetic visualisation of uncertainty in data as a means to navigating business risks and making better strategic decisions

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Keywords: Uncertainty, Data-Visualisation, Strategic-decision, Strategic-management, Trust, Risk, Decision-making, Insight

Abstract:

The COVID-19 pandemic has changed the global business landscape, with many companies now faced with an entirely new set of challenges and an uncertain future. As a result of this we need to consider how we identify and present critical areas of uncertainty to help businesses navigate risk and make better strategic decisions that steer them towards sustainable sources of growth and profit.

This paper will explore the practice and use of uncertainty visualisations by documenting a series of interviews highlighting the experiences of people from an array of different sectors and organisations (i.e. medical, business, environmental, civil service etc.). These diverse participants/ organisations have been strategically selected in order to provide a more holistic insight into how the application of uncertainty visualisations can/ has aided the planning and decision making of each organisation. The authors are interested in how the participants dealt with and designed the visualisation of uncertain data and if/ how they changed their strategies in accordance to the data presented and finally, the impacts it may have had on them and their organisation. Interview questions were designed to allow participants to express how they approach visualising uncertainty and the influences it presents on their decision-making process.

The findings display the true influence uncertainty visualisation had on an organisations ability to plan for future events. Interestingly, the interviews highlighted how the positive opinions of depicting uncertainty in data visualisations from a data scientist perspective differed from reality of the visualisations produced. Participants expressed their responsibility to portray data in a format that could be easily interpreted by executives or be used to reinforce a decision that had already been made. This research supplements the existing research highlighting the ignorance displayed by many executives who are reluctant to engage in data-drive decisions despite the proven profitable influence for future planning.

Introduction:

Following the sudden and rapid changes caused by the global pandemic businesses, were required to alter their operations and to seek alternative methods to plan and prepare for future unexpected events. Businesses with little to no contingency plans were strained to rethink years of strategic planning in order to 'stay afloat' amidst the unforeseen circumstances. In order to confront the new challenges faced and navigate the uncertain future businesses must explore alternative methods of contingency planning and adopt the change from solely basin decisions on gut instinct to data-driven analytical decisions or a hybrid combination. Businesses have the potential to plan for unforeseen events through utilising historical data and accepting possibilities of uncertainties occurring. As discussed by Oliver & Parrett (2018), the changing dynamics in the business world can present uncertainties that can make it difficult for executives to envision such long-term planning. Moreover, the prospects of planning for events in a market that has not yet emerged can create a burdensome challenge for businesses. However, despite the time-consuming and troublesome tasks presented, the implementation of contingency planning can allow a business to quickly address problems which could halt the operations and can allow the business to plan for not only successes but failures (Milano, 2019).

The research presented in this paper explores the use of aesthetics in uncertainty visualisations to influence the decision-making process. In doing so, it aims to support contingency planning and hence the strategic decision making for businesses growth. In detail, the paper will discuss the findings from a set of semi-structured interviews which explored participants experiences when applying uncertainty visualisation and aesthetic design to benefit their strategic decision making and future planning. These interviews provide a snapshot of how the introduction of uncertainty visualisation across different sectors can influence and support the decision-making processes for future events.

Business Strategy, Technology and Uncertainty:

COVID-19 has caused businesses around the world to face significant uncertainties from multiple sources, e.g. market, regulations, technology, and finance (De Lessio et al., 2015). In terms of technology, the pandemic has caused massive economic disruption and has led many companies to fast track to a digital transformation of delivery and service. According to a McKinsey Global Survey of executives (2020), their companies have accelerated the digitisation of their customer and supply-chain interactions and of their internal operations by three to four years (McKinsey & Company, 2020). This rapid transition to the digital has meant many companies have had to take a new approach to their business strategy and several adjustments and changes have had to be made to maintain a smooth flow of working operations. In many ways, companies have been thrown into the world of IT service management (ITSM) without formally realising it (i.e., they are needing to manage their new IT environments in order to provide value for their customer whilst also being cost effective and competitive). For many of these companies, a good set of IT services will be the new normal (and necessity) and will

be the strategic driver for their business value. Without a doubt, it will be organisations with a strong IT service management capability that will form the successes of the future.

In the meantime, and in the midst of trying to cope and understand this acceleration but also the fast evolution of the digital, many businesses are finding the making of strategic decisions and planning much more difficult. They are constantly needing to be responsive and ready to adjust rapidly to changes. As Shah (2020, pg.1) highlights 'This calls for a complete removal of rigid structures and a shift towards a data-driven, technology-powered enterprise that consists of empowered team members and strong leadership'. In this mix of data, technology, and leadership, comes other uncertainties (i.e. COVID-19, Brexit etc). Moreover, despite improved data analysis techniques, a lot of market developments are becoming increasingly difficult to predict. This can be a big dilemma for businesses when they have to make strategic decisions based on uncertain information. A key factor here is how businesses handle uncertainty. One thing is clear, as Courtney et al. (2000) highlight 'underestimating uncertainty can lead to strategies that neither defend against the threats nor take advantage of the opportunities that higher levels of uncertainty may provide'. In their paper, Johansen et al. (2014) adopt the term uncertainty to include both the positive effects (opportunities) and the negative effects (threats).

Defining uncertainty as to the lack of certainty about the outcomes of a particular action, where uncertainty occurs at the limits of known knowledge (Wakeham, 2015). Moreover, the extent to which data can be interpreted as inaccurate or imprecise (Spacey, 2017). In the application of businesses, it is often seen that uncertainty is widely associated with risk. However, it is important to differentiate between the concepts of both uncertainty and risk. In business decision making uncertainty refers to being completely in the dark, that a business does not know what will happen next and cannot see the possible distribution. Risk on the other hand is similar in the sense of not knowing what will happen next, but the business will know what the distributions will look like (Ritholtz, 2012).

To explore the approaches to managing uncertainty in businesses operations we explore the frameworks of uncertainty reduction and uncertainty coping. Uncertainty reduction refers to financial risk management and uncertainty copying refers to strategic management planning (Simangunsong et al., cited in Snizahko 2019) .Whilst both uncertainty mitigation methods are critical for businesses consideration, the focus will be on the uncertainty coping framework by Miller (1992). This framework sets out a five-stage approach for coping with the uncertainty, flexibility, imitation, cooperation, control and avoidance (Miller, 1992 cited in snizahko 2019). The focus of this research is surrounding planning and mitigation strategies for businesses and the authors of this paper therefore will focus on the final stage of the Miller framework: avoidance. The avoidance stage will take place when the level of uncertainties within the business is unacceptable to proceed with the risks and unknowns (Snizahko, 2019). It is often found that businesses will delay their operations whilst they analyse the uncertainty and evaluate methods of uncertainty avoidance, this may include

waiting until there are viable methods of accurately predicting the uncertainty (Snizahko, 2019). Analysing the approaches that businesses take when managing uncertainty explores further the uncertainty management framework from Miller (1992). However, despite the inherent uncertainties, it is important for businesses to find ways to embrace this uncertainty to emerge stronger, more resilient, more flexible and in a better position to make strategic decisions.

Strategic decision making:

Decision making is an essential component in the drive for success (Jankelová, 2017) and can be the most important function of managers in any organisation (Noorai, 2012). Decision-making involves the generation of setting alternative plans that can be considered and the approval on the most appropriate to be executed (Bhushan and Rai, 2004). The process of decision making often involves identifying the issue, gathering intelligence, coming to a final conclusion and learning from past experience (Schoemaker and Russo, 2014). Unlike traditional decision making, strategic decision making is associated with the long haul and aimed at pointing the company in the top direction management want to take it (Bondigas, 2019). Strategic decision making is often associate with decisions that are big, risky and hard to reverse, of which will often result in significant long-term effects for a business (Papadakis & Barwise, 1997). These decisions can drastically influence the businesses performance and in drastic times a business's survival. Moreover, strategic decisions are commonly new & complex. It is therefore common these decisions will be primarily handled by the top leadership teams (Selart, 2010), with or without input from department managers or key employees (Bondigas, 2019).

Ackoff (1970), cited in Janczak (2005), categorised strategic decision making as one aspect of the planning procedure. That planning for future business events needed to consider both the strategic and tactical decisions aspects. Highlighting strategic decisions are those broad in scope which have long term effects and difficult to reverse. In comparison, tactical decisions are concerned with selecting the optimum methods of pursuing the goals set out in the strategic planning stages.

Strategic decision making is imperative for a business to ensure that they can utilise the businesses resources to improve the competitiveness and maintain a competitive advantage (Haslam, 2012). In the midst of the Covid-19 pandemic, it has reinforced that businesses need to begin planning for unforeseen events, whether that be with a financial buffer, available facilities or recovery plan strategies (Rigden, 2020). In reality many businesses who did not plan for unforeseen events would have had their strategy slate clean, allowing the businesses to learn from past experience and begin reconfiguring the business planning and decision making for the new reality (Howard, 2020). Moreover, businesses must consider their strategic thinking and the impacts on the business's performance, especially in times of organisational changes due to the need of sustainable development (Dionisio, 2017). In order for a business to plan strategically for future events they must derive insights as a basis of their decision making.

Insight:

Insight is concerned with the sudden interpretation of a solution to a particular problem with which the answer comes into conscious awareness or may seem obvious. It is common that this sudden expression of realising the answer can trigger an emotional experience (Kaplan & Simon, 1990 cited in Steenburgh et al., 2012). Not only can insight be concerned with the "eureka" moment but also the progressive and incremental increase in understanding a topic in which there is a discovery of new connections or inconsistencies (Black, 2019; Klein, 2013). Insight intrinsically relates to the moment of the 'aha', which is the sudden realisation of an answer or having an unexpected understanding of a problem (Webb et al., 2016). The sudden realisation of a problem can guide the viewer to make a decision in which they believe is correct. However, it is crucial to consider that the sudden realisation of a solution may be obstructed by the viewer's overwhelming subjective impulse to derive what they believe is the correct solution when the solution may still be inaccurate. Moreover, the sudden light-bulb moment of 'aha' feeling may in fact accompany ideas that turns out to be incorrect (Webb et al., 2016).

Although insight has been shown to relate to the 'aha' experience, in business the term insight can also be delineated as: "A thought, fact, combination of facts, data and/or analysis of data that induces meaning and furthers understanding of a situation or issues that has potential of benefiting the business or re-directing the thinking about that situation or issue which then in turn has the potential of benefiting the business" (Vriens & Verhulst, 2008, p.13). Indeed, the data and analytics can be used to provide a business with a better understanding of situations in which strategic, tactical or operational decisions may need to be made. Insights in business allows the decision maker to base a decision on more than just gut-instinct by reviewing the facts, data or analysis to derive a more meaningful and thorough understanding to problems and situations. Similarly jumping to the conclusion of attaining the correct answer on a single insight is discouraged, a business should review a broader set of insights to ensure a definitive positive correlation before making their decisions (Vriens & Verhulst, 2008).

In the business world it is important to adapt to the rapidly changing environment and planning for future events. Businesses can begin to accomplish this through data analysis with predictive methods such as regression analysis, this will allow the business to begin to harness the full potential insights the data holds (Ergle et al., 2017). New and innovative analytical technique can allow a business to grow and plan exponentially through fuelling discovery and innovations, data analytics can enable business to make faster and more evidence-based decisions (Henke et al., 2016).

However, despite the reasoning to trust data/analytics to provide insight for better decision making, it is reported that in a study of 2190 business executives only 35% admitted to having a high level of confidence in trusting data and analytics (Violino, 2018). Moreover, this untrusting relationship with data has drawn many executives to rely solely on their gut-instinct for decision making. In order to understand the causation of the underutilisation of data in business we must explore the reasoning why gut instinct is widely adopted in business decisions.

Gut instinct & Data-driven decisions

Strategic business decisions are traditionally based on one of two decision-making processes; intuition-based decisions that rely on 'gut feelings' or data-based decisions relying on advanced analytics (Deloitte, 2015). However, the vast majority of business executives were found to solely rely on their gut instinct for decisions (business.com, 2020), despite the proven benefit of providing insight that data-based decisions have shown (Kavale, 2021). The debate of gut instinct vs data-driven creates a divide between those who prefer to 'trust their gut' and those technology-minded individuals who want to see the data before any decision (Brook, 2020). Whilst most organisations acknowledge the benefits data and analytics have to offer, still many organisations struggle to reap the full benefits of data-based decisions and heavily rely on gut-feeling and consensus decision making (Delotte, 2015).

The authors of this paper do not dispute the sheer benefits of trusting your gut to make decisions, an executive with years of experience will have ample knowledge and expertise in their field to make a decision. However, the authors want to convey the risk and disadvantages that sole gut-instinct decisions bring to a business. Moreover, there is significant power in utilising a person's heuristics, individual knowledge, interpretations and memories (Stevenson & Hicks, 2016), but coupled with factual data-based knowledge can significantly improve the quality of the decision made (Williams, 2012). A report written by The Economist Intelligence Unit found that executives were constrained more by their ability to analyse data than by accessing it (EIU, 2014). As a method to facilitate executives understanding of data, they may seek to utilise the power of data visualisations to derive insight.

Visualisation, Uncertainty Visualisation and Aesthetics:

As the information age continues to grow, the requirements for businesses to transition their operations online causes an overwhelming consignment of data. To ensure businesses harness the full potential held within the data, it is critical to correctly interpret the data to go onto making informed decisions (Robert & Laramee, 2018). A common method of interpreting data is through the use of transforming the data into a visualisation. A visualisation offers a business the ability to view data in a graphical form, which can transform large and complex datasets into a form easily understandable (Sadiku et al., 2016). Visualisations capture a business's data in order to assist with communication, improved information seeking, data analysis and improved decision support (Zheng, 2017). Visualisations offer a strong method that can be used to systemically uncover hidden trends and patterns which might have gone undetected by the viewer (Uyan Dur, 2014). Moreover, humans gather more information through visuals than any other methods as visuals provide the highest bandwidth for communication between human and computer (Ware, 2004), this can speed up the ability to gather insight and understanding from data.

Making use of visualisations can benefit a business hugely if done accurately. Data within a visualisation is often to be said has more 'meaning' as it can allow a business to easily explore patterns and areas of significance, whilst helping the businesses to focus on specific areas of the data that require attention (Saranya, 2019). However, it is critical to consider that a data point

represented on a visualisation does not always represent the true data value, when the data point may actually fall elsewhere on the visualisation (Wilke, 2019). Furthermore, the visualisation of predictive data runs the risk of portraying what is deemed the 'most likely' event or the one with the highest probability when uncertainty is not visualised.

The visualisation of uncertainty relates to the representation of data alongside an additional dimension that will signify the probability, confidence, accuracy, or errors that can influence the interpretations and decisions based on the data (Boukhelifa and Duke, 2009). The visualisation of uncertainty can provide the viewer with an enhanced and in-depth understanding of what the data shows. This strengthening of understanding has been found to improve the decision-making performance and quality in specific tasks (Chung and Wark, 2016).

"Decision-making quality is improved from understanding the uncertainty in the data and information being used. Categorising uncertainty is a preliminary step towards reorganising and dealing with uncertainty in the decision-making process." (Kleineberg et al., 2019, pg.4-5). Through accurately depicting uncertainty, decision-makers are able to have a better understanding of what the data is showing them. Whilst most business decision-makers acknowledge there are uncertainties present, it is essential they visualise these uncertainties to strengthen their decisions.

It is important to consider that there is no optimal method of visualising uncertainty, and a business must review the data case-by-case in order to represent the uncertainty effectively (Levontin et al., 2020). Two of the most common representations of uncertainty in a visualisation are error bars and confidence bands. However, it is said that for a lay audience these are not favorable (Wilke, 2019). In order to effectively represent uncertainty into a visualisation, we may need to turn to aesthetics to give a competitive advantage to the non-specialist audience.

Aesthetics

The term aesthetics is often associated with the description of the appreciation of beauty within the field of art, regarding something that invigorates both the body and mind and awakens the senses (Cwthon and Vande-Moere, 2007). The application of applying aesthetics in a visualisation is more than manipulating a visual variable. It is often believed that applying aesthetics to a visualisation is the process of making a visualisation 'beautiful', when it actually has a practical aim of revealing underlying meanings and structures (Bennett et al., 2007). Applying aesthetic designs to a visualisation can encourage the creation of associations and meanings through feelings, intuitions, thoughts and memories (Carroll, 2010). The application of aesthetics in a visualisation can harness the power of both forms of decision making, data-driven decisions through the visualisation and gut-instinct supported by the aesthetic design.

Aesthetic designs play a vital role in everyday life and are a significant influence on our decision-making process (Bhaduria, 2016). Therefore, it is important to consider the effects of aesthetics design on decision making in a visualisation. Triggering an emotional response through the use of aesthetic design can create a powerful and persuasive driver on the decision-making process (Lermer et al., 2015). However, it is important to consider the influence caused by aesthetics designs

which may introduce bias into the decision made from the subjectivity of the visualisation designer. The visualisation designer's interpretation and influence on the aesthetic modifications may differ from the decision-makers. However, Quispel, Maes and Schilperoord (2018), state that subjectivity does not mean that the viewers are being forced to swallow the designer's opinions regarding the data. That the visualisation designer feels the need to add the aesthetic elements in order to enable the viewers to arrive at their own adequate interpretation of the data.

The challenges faced through the visualisation of uncertainty may start to modulate with the use of aesthetic designs. The visualisation designer has a duty not to introduce subjectivity into their designs but instead guide the viewer to statistical outliers or areas of interest. Moreover, the use of design elements and aesthetic design must help explain what the visualisation is showing and not be placed redundantly, such as the use of colour could be used to direct a viewer to what is important within the visualisation (Yau, 2011).

Study Design:

This qualitative study was conducted through a series of semi-structured interviews with participants from an array of industries (private sector, natural resources, civil service, medical). The study was designed in order to allow participants to expand on their own experiences with uncertainty visualisation and decision making within their respected fields. The questions were devised to enable the authors to probe the level of understanding participants had for uncertainty visualisation and their methods of applying it to real-world data problems. The semi-structured interviews lasted between forty-five minutes and one hour. The interviews were conducted through video conference (i.e. Microsoft Teams & Zoom meeting).

The questions were strategically designed with a logical flow. The first question prompted/ probed participants for their definitions of uncertainty visualisations and aesthetic design. This enabled the authors to establish participants understanding of the terminology immediately. The remaining questions were then designed to draw from participants past experiences within their respective industries. These questions include; "*Have you ever been in a situation where you found it difficult to visualise data in a way that portrays it accurately?", "In your job role have you come across visualisations that attempt to show you the confidence level, the reliability or the multiple outcomes of the data?" & "Have you ever attempted when portraying data (either in visualisations or not) to give an 'in depth picture' and provide details on the confidence, reliability and potential outcomes of the predictive data?".* These questions aimed to elicit an in-depth picture of the use of uncertainty visualisation and the importance of providing the decision-makers with an 'in-depth' picture of what the data affords/ shows. The questions encouraged participants to provide examples of where they were required to display confidence levels, reliability and probabilities in order to allow for data-driven decisions.

Not only were questions aimed at deciphering the participant's experience with depicting uncertainty, a range of questions focused on the design and how participants utilised aesthetics in their visualisations. These questions were focused on understanding the level of thought that

participants put into the aesthetic design of their visualisations and how these modifications may affect decision making. These questions included "*What role do you feel design aspects play with presenting data?" & "When you design your visualisations (or when you're presenting data) do you consider the influence and sensory perceptions you cause? E.g. triggering an emotional or affective response?".* The motivation behind these questions was to start to understand how different industries may consider the design of their visualisations and whether this influenced their decision making. By understanding how different industries contemplated the use of aesthetics in their visualisations, the authors believed it would provide a more holistic insight into the thought processes of displaying data for data-driven decision making.

Research Participants:

The main aim of this study was to explore how uncertainty visualisations and aesthetics design can influence participants decision making in a range of industries. Participants were strategically selected in order to provide a comprehensive understanding of how different industries utilise uncertainty visualisations for their decision making. Moreover, participants were selected through purposive sampling in order to allow the authors to control the number of participants from each industry. This method of sampling allowed the authors to control who was interviewed, on the condition that the participant consented to providing information (Tongco, 2007).

The selective nature of determining appropriate participants only considered the industry and job role in which the participant was affiliated with. Once an industry had been selected, only participants who deal with data science, data visualisations or decision making were contacted. Participants were contacted directly inquiring about their involvement in the study. No other parameters were assigned when selected participants which could introduce bias into the study.

A total of five participants were recruited, interviewed from five distinct industries. Participants consisted of two males and three females, all over the age of 18 years and all resided in the United Kingdom. A full breakdown of the demographic of participants:

Participant:	Gender:	Age:	Industry:
Participant 1	Female	22-35	Public sector- Bioinformatician
Participant 2	Male	36-50	Public-sector- Natural Resources
Participant 3	Female	51-60	Public sector- Census engagement
Participant 4	Female	22-35	Public Sector- Civil Service
Participant 5	Male	22-35	Private sector- Insurance

Table 1: Demographic of participants involved in the study.

Analysis:

The qualitative research method was selected for its ability to gain insight into specific situations and meanings through the subjective experiences of the participants (Palmer & Bolderston, 2006). All interviews were recorded to enable the researcher to transcribe the information into an exact text replication. A thematic analysis of the results allowed the researcher to begin to interpret the data. In order to assist in the data analysis, the software NVivo was used to determine trends and patterns in the qualitative results. In addition, to support the analysis, the authors will generate vignettes to probe specific questions about uncertainty and decision-making.

Vignettes

Vignettes will be used to present the results as they encourage articulation of perceptions, beliefs, attitudes and opinions from a set of participants as they respond to particular scenarios of situations (Azam & Mahadhir, 2017). Moreover, vignettes allow the authors to explore and gather insights from participants' authentic experiences and attitudes. Vignettes allow the reader to determine their

understanding of the participants experiences through their own personal opinions or attitudes towards the vignette (Erfanian et al., 2020).

The vignettes data analysis methods allow for the systematic review of each industry and build participants' personas in their respected fields. The vignettes allow the authors to identify and evaluate the perceptions and implementations of the aesthetic depiction of uncertainty in visualisations.

Results:

The results highlight differences in utilising uncertainty visualisations and aesthetic design across the array of chosen industries. It was found a participant's understanding and willingness to visualise uncertainty and include aesthetic designs were strongly influenced by the audience the data was intended for. A common trend through interviews appeared to be that participants acknowledged the benefits of visualising uncertainty, yet the determining factor of whether or not to depict uncertainty was affected by whom the final visualisation was intended for. Each respective industry had their own standards and stakeholders in which their creative visualisation freedom was constrained by.

One participant (p4) expressed the importance of providing clients with an 'in-depth' picture of what the data shows but often clients only wanted the 'bare-minimum'

"From my perspective, I think it's good to show everything and if the client doesn't ask for that and they just want the minimum that's what you get, they just want basics, showing them a load of information they don't want could have a negative effect on the relationship" (p4)

Another participant (p2) expressed their concerns with providing the in-depth picture:

"Sometimes I think even going too much into the detail almost assumes that it is up for debate still." The comments raised by participants express a controversial opinion on whether providing the additional dimension to data that uncertainty brings warrants sufficient benefits. The comments on 'showing everything' versus 'too much details' raises the questions on information overload. Moreover, information overload is when providing excessive amounts of information to a person attempting to make a decision, which in turn impeded the decision-making process (The Interaction Design Foundation, n.d.)

Interestingly, the participant (p2) explained that visualisations are often not used to facilitate the making of data-driven decisions, but instead used to reinforce a decision already made. When asked,

"*How do you think decisions are affected when you give an in-depth picture of what the data shows (i.e. confidence)"* the participant responded with:

"Do they actually want that a visualisation or do they want you to confirm the decision they've already made? So sometimes if you tell them something, and they're not sure, they'll just ignore you. We like to think we're driven by the data, but we're not. So, I think we're asked to produce things after the decision has really already been made." (p2). This interesting response reinforced the potential that business decision makers are still relucent to utalise data effectively and instead follow gut instinct. Despite the benefits of gut instinct and 'following your gut' it is reported that business which utalise data for decisions are 5% more productive and 6% more profitable than their gut-trusting competitors (Business.com, 2020).

Through conducting analysis several key themes arose in which participants could be said to experienced uncertainty visualisation and aesthetic designs in contrasting circumstances. The authors categorised the different experiences to empathise better and understand the situations which accompanied each situations participant found themselves in.

The following sections displays 4 Vignettes that were derived from the interview data which illustrate the different personas of dealing with uncertainty and aesthetics in data visualisations. The personas are broken down into '*The confident but restricted*', '*The confident and unconfined*', '*The unconfident and unconfined*' and the '*The cautious visualisation designer*'

Table 2: Vignettes personas.

All participants had past experience in building, designing or using data visualisations in their current positions. The following Vignettes show the differentiation in experiences when dealing with uncertainty and aesthetics in a visualisation for improved decision making.

Vignette 1: The confident but restricted: (Confident to visualise uncertainty in their visualisation but are restricted by what they are allowed to include in a visualisation)

- **What comes to mind when you think of uncertainty in a visualisation?** I think of displaying what the confidence or probabilities are within the data such as providing error bars or ranges for example. I think of a visualisation that shows alternative possibilities for the data to go.
- **How do you feel visualising uncertainty helps a decision maker?** Displaying uncertainty can show the viewer if there are any significant gaps in the research. It allows you to consider all your options because you could go down one route and then realise it's not going to work. I think It is best to consider all the avenues
- **Do you often visualise uncertainty?** I am restricted as to what I can include in my visualisations. My visualisations are passed to executives and decision makers who do not have a good understanding of data analytics and therefore only want the bare minimum. I often question if their decision has already been made before they see the visualisations.
- **How important do you feel design plays in a visualisation?** I think it's critical because I am a visual learner, and I can infer quiet a lot from a visual instead of text. I also think it makes a visualisation a lot more engaging and interesting.
- **Do you think design can trigger emotional and affective responses?** I think it depends on the person and what they want to take from the data, I do think you need to be cautious you do not add too much bias into the visualisation and consider the type of effect you're trying to achieve.

Vignette 1 – The confident but restricted

Vignette 2: The confident and unconfined: (Confident to visualise uncertainty in their visualisation and has complete freedom as to what they include in their visualisation)

- **What comes to mind when you think of uncertainty in a visualisation?** I would say it would be using coloured bar to represent the confidence intervals and the uncertainty that sits around the data.
- **How do you feel visualising uncertainty helps a decision maker?** I think they allow you to give more evidence for your decision, especially when you're making these bold claims it can show how accurate or the confidence there is in the data.
- **Do you often visualise uncertainty?** In my field we have a particular set way of displaying uncertainty in our visualisations. It has become an industry standard and if we don't display the uncertainty then our work won't be taken any further. The decision makers and viewers in my field understand the ways we display the uncertainty
- **How important do you feel design plays in a visualisation?** The whole point of a visualisation is to display information in a way that is visually pleasing and to save the reader from trawling through loads of text to find an answer.
- **Do you think design can trigger emotional and affective responses?** I would hope that data speaks for itself and a person is not too influencing based solely on the design of the visualisation. However, I suppose it has given me something to think about when I design my visualisations.

Vignette 2 – The confident and unconfined

Vignette 3: The unconfident and unconfined: (The vignette is not confident with the visualisation of uncertainty and has complete freedom to include what they want in their visualisation)

- **What comes to mind when you think of uncertainty in a visualisation?**
  I am not sure what uncertainty in a visualisation is, but for me a visualisation must just make sense and is not complicated. The term uncertainty makes things sound complicated.
- **How do you feel visualising uncertainty helps a decision maker?**
  I think that is could help people share their knowledge and understand it better.
- **Do you often visualise uncertainty?**
  We work that once our data goes past a certain threshold, we class it as reliable and do not represent and alternative paths. We do consider the uncertainty in our testing data sets before to ensure integrity.
- **How important do you feel design plays in a visualisation?**
  A massive importance, I see design as the bridge that links the data together. It's unfortunate that there are often differences in the way a designer would visualise uncertainty and a scientist, they need to look at it from each other's perspectives.
- **Do you think design can trigger emotional and affective responses**
  A visualisation designer has a huge responsibility when it comes to portraying data in a visualisation. The integrity and not introducing bias is in the visualisation designers' hands.

Vignette 3 – The unconfident and unconfined.

Vignette 4: The cautious visualisation designer: (Cautious about the visualisation of uncertainty and the design of a visualisation – Mostly has freedom with what they choose to include)

- **What comes to mind when you think of uncertainty in a visualisation?** Data which might be messy or unclear. Anything where the data just doesn't look obvious straight away.
- **How do you feel visualising uncertainty helps a decision maker?** I think it can make the decision harder for the viewer as you have now made it more real for them. That's the problem with communicating this stuff the person needs to understand it, and well most people don't.
- **Do you often visualise uncertainty?**
  I think it comes down to who the data is for, what they are asking me and if uncertainty is needed. I think sometimes it comes down to that people are just bad at understanding uncertainties.
- **How important do you feel design plays in a visualisation?** It is critical to a visualisation but it's unfortunate that is critical because it should mostly just be about the data not the design. However, I do think it can help a visualisation is done correctly. If a design is bad it can ruin the visualisation completely.
- **Do you think design can trigger emotional and affective responses?** I think you have got to be cautious about the type of effect that you are trying to achieve. I do still think it comes down to the data and who the visualisation is intended for.

Vignette 4 – The Cautious visualisation designer

Discussion:

Through using the vignettes analysis approach the authors have been able to compare and contrast the application of uncertainty and aesthetic visualisation for decision making through the personal experiences of data scientists and visualisation facilitators. It is clear from the research that all participants acknowledge the benefits and constructive use of considering the uncertainties in their visualisations.

A summary presented by one participant (p2) nicely summarised the importance of uncertainty visualisation and providing the viewer with an in-depth picture of what the data shows:

"We know life is uncertainty and really risks, so what do you want to do stumble around in the dark? Or would you like a flashlight to help you see where you're going? And I feel that a good data visualisation and good analytics is exactly that…It's like having a flashlight and its helps illuminate where you're going" (p2).

What is clear from that description is that all understanding of uncertainty in a visualisation is well defined from a statistical perspective from some i.e. *The confident but restricted , The cautious visualisation designer , The confident and unconfined* and best defined from a user experience or decision maker perspective from others i.e. *The unconfident and unconfined.*

The vignettes portray three sides to the visualisation of uncertainty: the restricted, the unconfined and the cautious visualisation designer. Two of these categories (the restricted and the unconfined) create a divide as to the level of freedom the visualisation designers have when depicting uncertainty in their visualisation. The most common factor causing restrictions was found to be the executives or decision makers ability to understand the additional dimension to the data. This was especially apparent in those industries where the data scientist/visualisation designer acknowledge the true benefits an in-depth picture could have provided.

One participant (p4) detailing the potential effect of a visualisation depicting the probability of an event occurring:

"If you're being told something is 90% accurate you would be very happy. You probably wouldn't even worry about that extra 10%. Whereas if you're showing the effects of that 10% then it might make you look into the other options, bringing those ideas in the back of your mind to light" (p4).

The comments raised by participant four reflect the findings of Sniazhko (2019) surrounding how the inclusion of uncertainty may influence the decision-making process.

Similarly, another participant (p5) expressed the benefits of depicting uncertainty and providing an in-depth picture:

"It can help build users general confidence in a visualisation" (p5). Interestingly, the idea raised by participant five on how uncertainty visualisation may build a user's confidence is not shared by the wider visualisation community. In fact the opposite is suggested in that communicating uncertainty may cause the data to become less trusting and resulting in lower confidence (Fischhoff, 2012).

Despite participants expressing their preference to visualise uncertainty and provide an in-depth picture they also told the story of how this additional data was either never asked for, never wanted or could never be understood. Participants touched upon how the visualisation of uncertainty or providing the viewer with a more thorough picture would in some cases act as more of an obstacle than tool in decision making.

Consistently participants would express their concerns or reasoning behind not visualising uncertainty. Statements such as "I think if they've already made the decision, you can only use the data to prove it or to give them more evidences. Rather than to influence their decision." (p2), depict circumstances where the visualisation is not used to influence decision and mostly just to give evidence on a decision that has already been made. Another participant (p1) expressed how displaying uncertainty can provide a viewer with added confidence in the analysis. However, goes on to state "In some research it would be very beneficial giving that confidence interval, whereas other

research might need to be more specific and direct, in which providing the confidence interval would just be null and void." (p1). This raises the question of whether in certain situations business executives and decision makers have the knowledge or trust surrounding the data in order to influence their strategic decisions.

The authors of this paper feel that the design of a visualisation may play a key influence in the decision of executives and decision makers reluctance to utilise data-driven decisions. Moreover, whether the aesthetic design of a visualisation could play an important role in influencing or persuading decisions (Bhaduria, 2016 ; Lermer et al., 2015).

Figure 1: Word frequency query: What role do you feel design plays in a visualisation.

The data scientists and visualisation designers we interviewed reflected positively on the importance of well-designed visualisation. Moreover, participants highlighting key terms such as 'critical, accessible and important' to express the vital role design plays in a visualisation. However, when we asked for participants views on the application of design and the thought process that went behind the selection of design elements to create aesthetically considered visualisations the responses were less pensive.

When discussing the design elements which can be applied to a visualisation all participants firstly turned to the use of colour (both in the application of making a visualisation more 'pleasing to the eye' and in the depiction of uncertainty). Some participants also touched upon the use of size and shapes within their visualisations to portray data (i.e. axis, values and layers).

When participants were then asked how they felt their selected designs influenced a person's decisions or caused emotional and affective responses, participants were at a loss. It was evident that the design elements used in the visualisations were simply to distinguish data or to make it visually pleasing.

One participant spoke how they can be influenced on their selection of colours and designs based on previous experiences and that they "can't really pinpoint an emotional or more of a though provoking response I'd be looking for in the viewer. " (p1). Another participant similarly said "No, I never thought that deep into it if I'm honest…I'm aware you can make things worse like using reds...but it's not something I've come across myself" (p5). These statements raise a question of whether more can be done by the visualisation designer in order to aid the executives and decision makers through the additional dimension of data.

Conclusion:

The quality study reported in this paper has preliminarily investigated the experiences and thought-processes around the visualisation of uncertainty and aesthetic design to improve decision making. Through combing a thematic analysis with the use of Vignettes, the authors have analysed the key characteristics present in situations participants found themselves in. Moreover, the experiences provided details in which accentuated the actions participants took when faced with these situations.

What is of particular interest is the limited ability for data scientists to portray visualisations with an in-depth picture to improve decision making. On numerous accounts the data scientists/ visualisation facilitator has acknowledge the benefit uncertainty visualisation can provide through enabling a data driven, fact driven and evidence-based decision. However, the executives/ decision makers ability to make use of this additional dimension in the visualisation is severally hindrance by their lack of skill to understand the extra data.

Nevertheless, not all blame can be pinned on the business executives leisurely approaching to learning about data analysis. As one participant (p3) explaining, **the visualisation designer has a huge responsibility with cannot be underestimated to display data in a way that can be understood by everyone.** This raises the question of whether the visualisation designer is doing enough in order to help and guide the business executives or decision makers to utilise the full potential of their data analysis. This research provides evidence that the visualisation designers interviewed acknowledge the benefits of uncertainty visualisation and design yet can be inattentive to the messages and influences caused by their design choices.

Two core assertions can be derived from the findings of the study.

1) Business executives do not utilise the full potential of data and data visualisations because they do not have an extensive understanding. Therefore, business executives and decision makers rely on their gut instinct to make important strategic decisions.

2) Visualisation designers acknowledge the benefits of uncertainty visualisation to provide the decision maker with an in-depth picture of what the data shows. However, they do not utilise or think about how design can be used in order to depict uncertainty. Moreover, that design is often used redundantly in order to make a visualisation more appealing and not more comprehensible.

Evaluation & Future Work

The authors of this paper suggest that visualisation designers should be encouraged to use aesthetic visualisations in order to depict uncertainty and provide an in-depth picture of what the data shows. The aesthetic visualisations will allow the visualisation designer to depict their data both visually pleasing but also have an underlying consideration of how the combination of design elements may enhance the viewers understanding and messages derived from the data. The visualisation designer must have an understanding of how the designs they select may have an influence and/or cause an affective response to their participants.

The focus on this paper has been the intersection of data scientist and the visualisation designer, moving forward the authors feel that it will be important to further explore the rationalisation of gut-instinct versus data driven decision from the executives or decision makers' perspectives. This, will enable them to gain the perspectives of the executives/decision makers and draw a more in-depth understanding as to why the adoption of data driven decisions are frowned upon in the business world. Although the authors acknowledge the benefits of relying on gut instinct to make low level or short period decisions, strategic long-term decisions we maintain should be steered by data-driven or at least a combination of gut-instinct and data-driven decision making (a hybrid method).

As a means to address the visualisations designer's ability to depict uncertainty through the use of aesthetic design, one author's PhD work is aiming to address this problem. The author's PhD work is - to address how different aesthetic designs may be used to target different situations in which uncertainty is present in a visualisation. An uncertainty visualisation framework will be constructed to help guide the visualisation designer to select aesthetic combinations (both design elements and principles) in order to best represent their data. This proposed framework will provide the visualisation designer with a comprehensive understanding of the level of effect they can typically expect from their aesthetically depicted visualisations.

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Awareness of Machine Learning techniques used by (SME) for their cyber security

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Keywords: Cyber Security, Machine Learning, GCHQ, Algorithms AI, Big Data, Data Science, Cyber Threats and Attacks

Abstract:

Artificial Intelligence (AI) and Machine Learning techniques have become vital in the growth and dependencies of small and medium enterprises (SME) in the UK in the operations and commercial environment. The study surveys the key Machine Learning techniques used by SMEs and for their cyber security. SMEs have developed their own cyber regimes and awareness towards understanding the notion of AI and Machine Learning and this understanding is explored for both running of their day-to-day business and its application to detect and protect the cyber space from threats and attacks in which they work in. There has been previous research into Machine Learning techniques being used to keep the cyber space safe, however, there is no study which particularly looks at which Machine Learning techniques are being used by UK SMEs for cyber security. Much like the security guards and policing that happens in the real world, the virtual world is now calling on super giants of AI in particular Machine Learning techniques to be embedded in such the likes of a secret service covert operation to help in protecting data being distributed in its millions into cyber space. This paper will share the success stories of Machine Learning and its usage in cyber security. The methodology adopted focusses on structured survey questions on a selected sample number of respondents and directed to the SMEs management, technical and non-technical professionals. The papers survey was also conducted during the Covid-19 pandemic which rose particular interest in how the respondents replied and the high survey returns for answers. Based on the analysis and findings, this small study of under 30 participants revealed that these SMEs had the appropriate Cyber Security Packages in place but not necessarily aware of its full potential. The success story of this paper draws the conclusions emerging from business and organisations needing help of government policies and process, and working together to combat hackers, malicious actors and their bots and manage the best they can to stay ahead of the game. These aspirations can be reached with ensuring those involved with devices have been well trained and understand the importance of communications to apply appropriate safety processes and procedures particularly during the Covid-19 pandemic that has led to a cyber pandemic causing the grievance of cyber threats to increase tremendously.

This article also highlights an important funding gap that could be fulfilled by the government to support SMEs in the form of grants, subsidies, and similar financial assistance through various public sector policies. It is apparent that awareness from SMEs in this pool of participants were poor and more work in raising awareness or being informed needs to take place.

The study findings add to the research that awareness is still on a learning curve and yet to be defined. Whilst Machine Learning has produced cyber security challenges, this paper will perform its deduction and quantification of its examples and how strong the perception and awareness of Machine Learning is penetrating the UK SME business mind.

Introduction

Artificial Intelligence in its golden years gave birth to various buzz words such as Robotics, Turing's Test, Thinking Machines, to modern day terminologies such as Machine Learning, Data Science, Big Data and Algorithms [1]. In 1968, Arthur C. Clarke imagined that by the year 2001, a machine would exist with an intelligence that matched or exceeded the capability of human beings. He went on to write the story 2001: A Space Odyssey which was later turned into a film of the same name by Stanley Kubrick. The main character, HAL 9000 who was indeed this machine that was intelligent [2]. Robocop in the 80s was the face of Artificial Intelligence then, and it was through this robotic creation stemmed the insight and growth that is today Machine Learning, and our understanding of its algorithms [3]. With the release of the movie in 1987, the way we viewed AI evolved into everyday usage in industry through everyday interactions over the internet with the likes of superpower companies such as Amazon and eBay investing in these intelligent technologies. Fast forward to 2014 and Artificial Intelligence algorithms continue to learn and beat humans at their favourite games ranging from the video consoles Atari to the classic board game Go [4]. Their capabilities go far beyond the expectations of conquering human hobbies but lend further into everyday chores and events in our daily lives. In a BBC Interview with scientist Professor Stephen Hawking in 2017,[5] he had discussed how efforts had been made to create thinking machines that potentially could pose a threat to our very existence. He added that:

"The development of full artificial intelligence could spell the end of the human race."

Imagining a crystal ball was at our mercy, and that the future was foretold, the realisation of AI and Machine Learning could advance too far ahead of our time to ever realise the effects it has on society and if we could ever reverse its effect on our lives. Imagine the consequences of this scenario and how humans and our limited understanding of AI and Machine Learning would react and must learn and live together with machines that could be as intelligent as us. We perhaps could not even imagine what life would be like if technology were removed as it would be silently embedded. As AI and Machine Learning progresses, could humans go "back in time" to how we used to live? Hard as it is to imagine, the realisation has taken one step further in that the pandemic of COVID-19 in 2020 has accelerated the usage of AI and Machine Learning into new realms we perhaps cannot even shake to understand. AI and Machine Learning has finally arrived in its version of Industry 5.0 and the pandemic.

Looking back, Industry 4.0 [6] displayed a myriad of varying technologies and platforms post-pandemic, it was with no surprise that pre-pandemic was confusing enough for business to make certain choices and make decisions based on what worked best for their business. Capitalising on AI and Machine Learning would be to improve capabilities and financial management. In an article written in the International Institute for Management Development (IMD) [6] based in Lausanne, Switzerland, IMD focused on Industry 4.0 and Covid-19, and gave thought to the notion that AI is most effective when there is a historical database to learn from and exploit, to better predict the future. This is indeed valid, as the more historic data or Big Data [7] there is to mine, there is a better predictability chart to show the "best fit" line. The same article goes on to discuss how perhaps in the past, businesses looked at business drivers and other complex events to drive their business forward when it could be seen at a simpler angle to succeed. The papers go on to discuss how the pandemic has created a simpler model to work from to survive. Supply and demand have taken a shift and its platform and demographics have moved to a more resilient virtual environment free from Covid-19, that environment being cyber space. Even the likes of Chatbots have emerged to manage online interactions linked to the use of artificial intelligence (AI) applications. Chatbots [8] have replaced people and Machine Learning is now learning everything about us and how humans behave. Machine Learning is now evolving in how we interact online and adapt to our needs and surroundings.

With Industry 5.0 [9] overtaking Industry 4.0 rather quickly, the desire for humans to interact with machines is vital. It is no wonder the assumption of people's awareness is at stake so as to minimise the statement earlier generated by Hawkings, that this will be the end of humanity, indeed humans have now got to get to the next level of design with Machine Learning and start interacting with machines at a higher rate of speed.

AI: Machine Learning

The UK's answer to providing intelligence and information assurance to the government and armed forces is the Government Communications Headquarters (GCHQ). The GCHQ is an intelligence and security organisation with a mission to keep the UK safe. In recent news published September 2020, ten tech cyber security start-up companies using AI, Data Science and Machine Learning were selected to benefit from the 12-week support programme, based out of GCHQ's Manchester office. These included firms which use AI to alert haulage companies to stowaways in their containers, data to determine how busy trains are to manage social distancing and AI and Machine Learning to identify and prevent the spread of fake news [10].

Another article published back in April 2019, led to guidance being written on the National Cyber Security Centre website (NCSC) [11] which is now, part of the GCHQ. This guidance offered information on assessing intelligent tools for cyber security in the form of AI and Machine Learning. The NCSC provides a single point of contact for SMEs, larger organisations,

government agencies, the general public and departments and also collaborates with law enforcement, defence, the UK's intelligence and security agencies and international partners.

Across the continent in China back in 2016, Machine Learning methods were used in predicting China's SME credit risks in supply chain finance software. A new integrated ensemble machine learning (ML) method was trialled and sample of empirical analysis that comprised of two data sets on a quarterly basis during the period of 2012–2013 were tested on. One included 48 listed SMEs obtained from the SME Board of Shenzhen Stock Exchange and the other one consisted of three listed core enterprises (CEs) and six listed CEs that were respectively collected from the Main Board of Shenzhen Stock Exchange and Shanghai Stock Exchange. The experiment showed results of a new Machine Learning method, RS-RAB, that possessed an outstanding prediction performance and was very suitable for forecasting the credit risk compared with three other Machine Learning methods as discussed in this paper [34]. In another example, Machine Learning can be used to identify and manage physical fatigue is a recurrent problem in running that negatively affects performance and leads to an increased risk of being injured. Here inertial measurement units (IMUs) that distinguish between fatigue levels during an outdoor run can be further analysed using machine learning classification algorithm trained on IMU-derived biomechanical features, and what is the optimal configurations to do so. A random forest classification algorithm was trained with selected features from the 400 m moving average of the IMU-derived accelerations, angular velocities, and joint angles. It was concluded in this paper that optimal combinations of IMU locations at the lower limbs and trunk could detect this fatigue allowed the younger runners to take precaution and care when choosing a sport like running to not over exert or cause injury in later years [35].

Machine Learning stems from a branch of Artificial Intelligence and is defined by computers being able to develop a model and learn over time without prior learning then improve this model like a human [12]. Over time the computer starts to develop and improve based on its interactions as its software grows and develops. Uses of Machine Learning algorithms, as suggested by Hewage, C. et al, 2018, one example being to model polyalphabetic ciphers for decryption. In other words, to break the code following a set of sequential mathematical calculations and models of evaluation. This paper delved into selected algorithms such as hill climbing, genetic algorithm and simulated annealing to decrypt sample codes [12]. Similar to its predecessors and founders in code breaking back in 1941, the Enigma enciphering machine which was used by the German army to send messages securely was later on succeeded in its code breaking by the famous Alan Turing who played a key role in his invention of the machine known as the Bombe, which significantly reduced the work of the codebreakers [13].

In the case of cryptology, designs of such algorithms in Machine Learning fundamentally lies within the strong structures of cryptology. As cited in the paper by Hewage [12], 'Cryptology is the art and science of making and breaking "secret codes"'. The same paper goes on to divide Cryptology into two sub-divides as shown in Diagram 1 below:

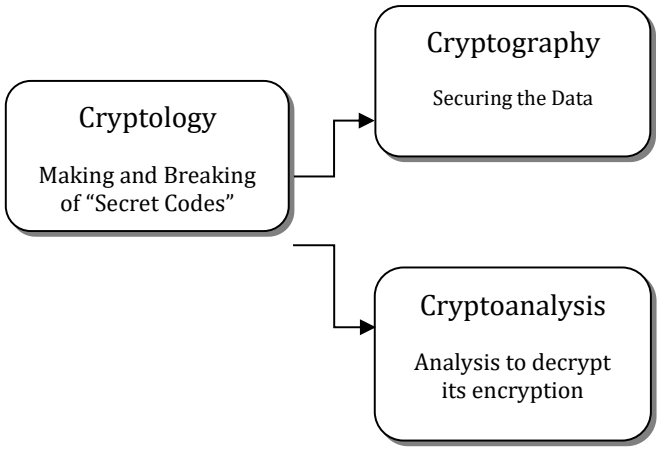

Diagram 1: Cryptology diagram(Prepared by Authors)

This paper focused its decoding using algorithms that were inspired by nature to tackle complex problems. In particular looking at the ant colony optimisation in looking at how social behaviour influenced the findings of the shortest paths leading to the end goal [14]. Back to Hewage, their paper focused on hill climbing algorithm to decrypt sample codes as ways and means to obtain results through collection of data and getting results at each step of the "climb", whilst the genetic algorithm took an evolutionary approach and looked at how the results mutated and changed over a time period. The simulated annealing was a process of heating and cooling and potentially trying to reach a local maximum to gain results, and worse solutions were discarded, filtering to obtain the best possible solutions available. The paper unites the understanding of Machine Learning and further its categories inspired by nature. Machine Learning can be divided into three subcategories as shown below as described in Diagram 2.

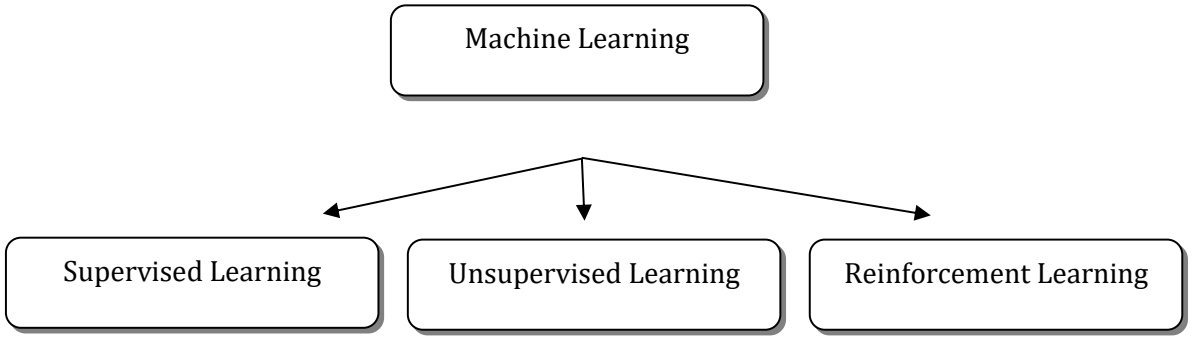

Diagram 2: Three categories of Machine Learning[15]

The three categories defined above in Diagram 2 are methods in which to train Machine Learning algorithms. In order to understand the advantages and disadvantages of how these algorithms work, this is based on the dataset used and injected into the algorithms. These data are classified as Labelled and Unlabelled Data [16]. Machine Learning is unabled to move forward unless it has a dataset to work with. According to Buczak, A.L, 2015, there exists a variety of datasets to choose from depending on the experiments being conducted. For the interest of Machine Learning algorithms, the public dataset was discussed. DARPA 1999 and KDD 1999 are amongst many datasets that are currently used in the public domain. However, these datasets that contain more than 4 million records are hard to maintain and require human intervention when it comes to labelling the records. Depending on how these datasets are labelled will define the type of category of Machine Learning can be utilised to move an algorithm design forward [16]. These datasets sit very nicely under the DPA (Data Protection Act) 2018 and UK GDPR (General Data Protection Regulation). DPA and GDPR are important policy instruments regulating the framework for cyber security as well as data protection. This is important in the data mining and uses of datasets when experimenting with Machine Learning [16].

The three categories in Diagram 2 are defined depending on its structures of use. The first category is Supervised Learning, and this category is driven by tasks. It refers to the most basic types of Machine Learning where the learning algorithm is developed on data [17]. In the paper by Buczak, A.L, 2015 [16], Supervised Learning is further categorised into Classification and Regression. Classification refers to data points being set and examples of this in real life is predictive text in tweets in Twitter and product reviews in Amazon and eBay. Algorithms used here can be that of Support Vector Machines and Naïve Bayes (Bayesian). Regression is used to predict continuous values and examples of the algorithms are such of Decision Trees and Neural Networks. Real life examples are calculating temperature, insurance premiums, pricing, and number of workers to the revenue of a business.

The second category is Unsupervised Machine Learning. This uses datasets that are unlabelled which means that human labour is not required to make the dataset machine-readable. Thus, allowing much larger datasets to be worked on by the program [17]. Unsupervised Learning has two categories, Dimensionality Reduction and Clustering using many algorithms such as Decision Tree, Random Forest, Missing Values, Principal Component Analysis (PCA), Neural Networks, Fuzzy Logic and Gaussian. Dimension Reduction focuses on data compression, and hence reduced storage space leading on to reduced computation time and helps remove redundant features. Clustering refers to the task of dividing data into groups. Real life examples include identifying fake news, implementation of spam filter, identifying fraudulent or criminal activity online, and marketing campaigns.

The third category of Reinforced Learning is based on the psychological concept of conditioning. Reinforcement learning here works by putting the algorithm within a working environment with an interpreter and a reward system. The output result is then decided by the interpreter whether it is favourable or not. Reinforced Learning enables interaction with an environment through the means of a machine. An example of this is repeatedly playing a video game providing a reward

system when the algorithm takes an action [16]. In reference to an earlier statement, AlphaGo is an example of Reinforcement Learning.

Mobidev's Machine Learning techniques can be noted in Diagram 3 below, showing the representation of the Machine Learning story [18] and below table its uses in real life applications.

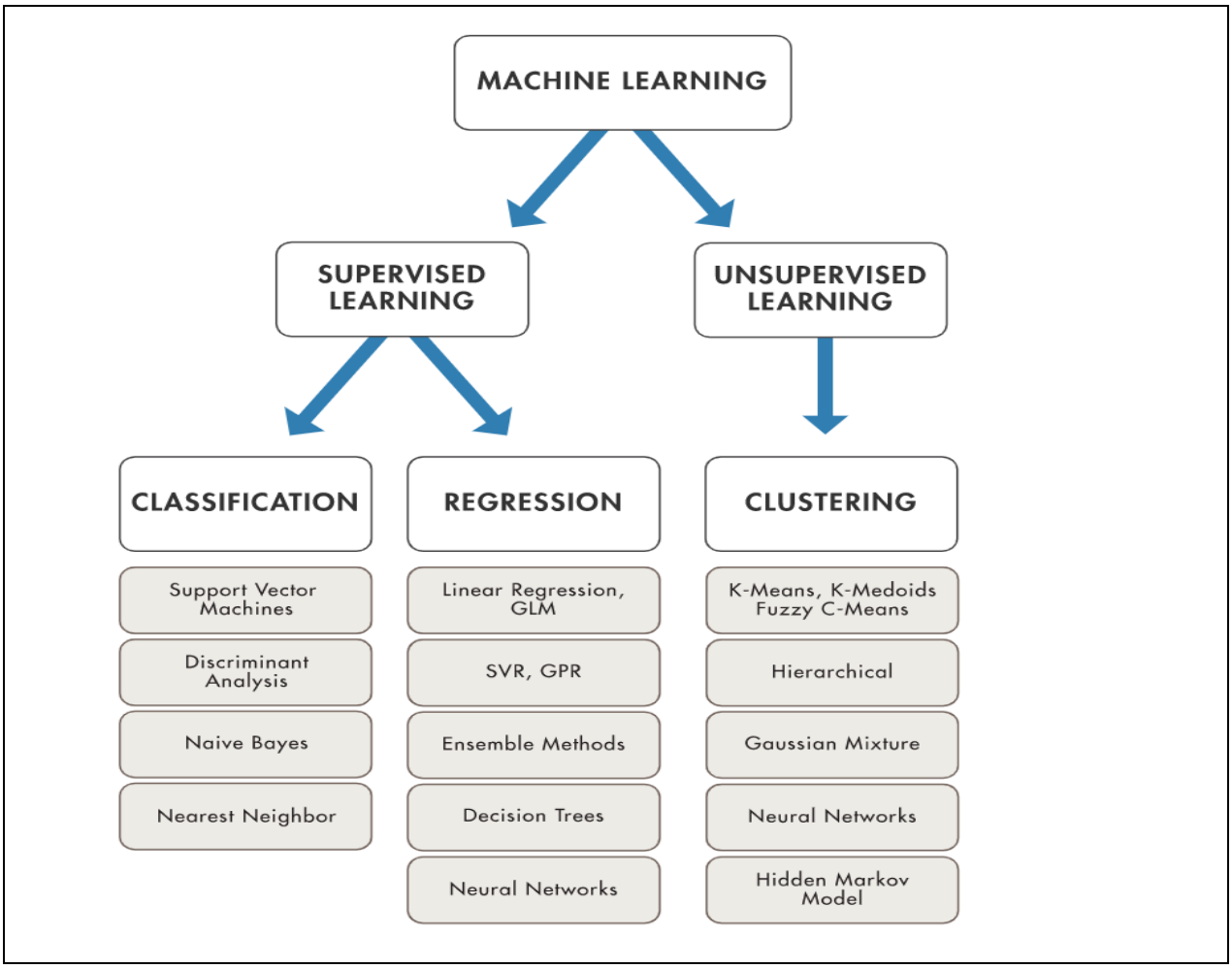

Diagram 3: Shows an understanding of Machine Learning; Methods, Techniques and Algorithm(Authors impression inspired by [17])

It can be seen from Diagram 3 above, that there are clear overlaps on various different algorithms and certain areas of Supervised and Unsupervised Learning. Reinforcement Learning on the other hand enables a machine to react with an environment and lends its algorithms to Deep Networks combining both Neural Networks and Deep Learning [16]. Whilst Neural Networks is used in Supervised Learning, Reinforced Learning takes its examples from the above Diagram 3 suggesting an overlap of algorithms being used depending on the real-life scenario and its applications.

Machine Learning in Cyber Security

In real life applications of the previous section of Machine Learning techniques and its algorithm, technology giants such as Amazon, Google and Facebook all have been gradually ramping up their security models in using AI and its usage of Machine Learning. These technology giants have used Machine Learning to focus on how they can use the technology to improve their customer service experience and further develop their customer engagement and behaviour plus complement their cyber security [19]. These technology giants have also created Machine Learning products to protect their own customers from cyber threats.

The below Diagram 4 gives a summary of various big technology companies that currently are using Machine Learning methods described in earlier sections plus its techniques and algorithms. It also shares reference points and success stories of where Machine Learning has benefited and helped these companies in securing their own internal systems from cyber threats.

In a paper by Lee et al. [20][21] observed that malicious spammers would exploit social media systems of these technology giants such as phishing attacks, malware, and promoting affiliate websites thus leading onto the development for detecting spammers in social network companies like Twitter, Facebook, and My Space. By developing specific classifications techniques enables the detection of email spam and phishing approaches that rely on data compression algorithms, machine learning and statistics that could inform the further refinement of the proposed approaches as shown below in Diagram 4. Supervised Machine Learning techniques were used in this paper based on Support Vector Machine (SVM) with its high precision as well as low false positive rate with its information and data feeding into the SVM classifiers.

Big Giant Technology Company	Machine Learning Method Used	Machine Learning Technique	Reference	Outcome and Results
Siemens Cyber Defence Centre using Amazon AWS	Supervised and Unsupervised Learning	Classification, Regression, Dimensionality Reduction and Clustering	[22] LAZIĆ, L., 2019. BENEFIT FROM AI IN CYBERSECURITY. In The 11th International Conference on Business Information Security (BISEC-2019), 18th October 2019, Belgrade, Serbia.	Build an AI-enabled, high-speed, fully automated, and highly scalable platform to evaluate 60,000 potentially critical threats per second.
PayPal, Visa, Mastercard	Reinforced Learning	Static Models and Self-Learning	[23] Orche, A.E. and Bahaj, M., Approach to Combine an Ontology-Based on Payment System with Neural Network for Transaction Fraud Detection.	Used Machine Learning in fraud management solutions to combat payment fraud. Using static models to identify fraud at a given moment by sifting through millions of past transactions. Identifying historical patterns of fraud and on self-learning techniques to adapt and recognize evolving fraud patterns
Darktrace in NHS	Unsupervised Learning and Reinforced Learning	Classification, Regression and Own Experience	[24] Vähäkainu, P. and Lehto, M., 2019, February. Artificial intelligence in the cyber security environment. In ICCWS 2019 14th International Conference on Cyber Warfare and Security: ICCWS 2019 (p. 431). Academic Conferences and publishing limited.	Uses Machine Learning to monitor raw data, such as cloud service interactions, transferred on a network in real time, without disturbing business operations and transactions. It also provides a direct view to all digital activities by reporting ongoing attacks or anomalies
Google- Gmail	Supervised Learning	Classification, Regression	[25] Proko, E., Hyso, A. and Gjylapi, D., 2018. Machine Learning Algorithms in Cyber Security. In RTA-CSIT (pp. 203-207).	Used Machine Learning via filtering not just incoming spam but identifying other abuses like Denial-of Service (DoS), virus delivery, and other imaginative attacks.
Tesla	Unsupervised Learning	Dimensionality Reduction	[26] Kim, K., Kim, J.S., Jeong, S., Park, J.H. and Kim, H.K., 2021. Cybersecurity for Autonomous Vehicles: Review of Attacks and Defense. Computers & Security, p.102150.	Used Machine Learning to secure Wi-Fi and browser vulnerabilities using 0-day exploits to limit tampering with autonomous vehicles which can be disruptive
Facebook, Twitter, MySpace	Supervised Learning	Classification	[20] K. Lee, J. Caverlee, and S. Webb, "Uncovering social spammers: social honeypots + machine learning", SIGIR'10, July 19-23, 2010, Geneva, Switzerland	Developed machine-based classifiers to recognise precision in social spammers

Diagram 4: Big Giant Technology Companies and their Machine Learning Techniques

Recent articles on the internet written by a variety of technology magazines suggests that Amazon's AWS (Amazon Web Services), Google's Gmail, and Facebook are also using their

Machine Learning knowledge towards their cyber security models to advance their threat detection as seen above in Diagram 4 [27]. Stephen Schmidt, Amazon CISO, mentioned that Amazon had a duty of care to ensure online safety of millions of people across the world leading back to their cyber security structure as explained in this article. Siemens Cyber Defence Centre that uses Amazon's AWS went on to build an AI-enabled, high-speed, fully automated, and highly scalable platform to evaluate 60,000 potentially critical threats per second. This success story has then subsequently improved their cyber security and its threats reduction [22]. In Diagram 4 it is also highlighted that Amazon on the other hand uses Decision Tree algorithms in its AWS Services and has expanded its services through Amazons Macie on which its design was to embed its intelligence to protect the network and works of Supervised and Unsupervised Machine Learning methods [29].

In another article posted on CSO online [28], in order to analyse threat endpoints on mobile devices running on Androids, Google had been able to use Machine Learning in identifying and removing malware from these devices. As clearly shown in Diagram 4 above, Google mail (Gmail) has seen success stories in its spam filtering not just incoming spam but by the use of Machine Leaning in identifying other abuses such as Denial-of Service (DoS), virus delivery, and other imaginative attacks [25]. Based on these Machine Learning methods, Amazon launched a new service to classify its data storage under the Supervised techniques of Machine Learning.

Diagram 4 above also shows the applications of a UK cyber security start-up company Darktrace, a company that had seen success around its Machine Learning solutions since 2013 [28]. Darktrace used algorithms within its software package to spot attacks within one NHS agency's network, and the threat was then mitigated without causing any damage to that organization. When WannaCry was the top cyber threat back in 2018, all Darktraces customers were not harmed, as the Machine Learning algorithms were clever enough to intervene and create a safe environment for them [24]. According to Vähäkainu, P., (2019), Darktrace uses their own mathematical algorithm Enterprise Immune System technology (EIS) and utilizes this Machine Learning technique combined with the Bayesian algorithms and other mathematical principles in order to detect anomalies for cyber threat detection within a network. The paper describes the technology using Bayesian probability theory and how Darktrace monitors raw data, such as cloud service interactions. The paper also explains how this data was then transferred onto a network in real time, without disturbing business operations and transactions.

Other companies to take up Machine Learning and its techniques as part of its cyber security frameworks as shown in Diagram 4 are the likes of PayPal, Visa and Mastercard [30][23]. These companies use Deep Learning algorithms to identify and prevent fraudulent behaviour within milliseconds before, during and after a transaction, as reported in the article written in November 2020. Mastercard also had experienced over 200 fraud attempts per minute which has allowed them to also utilise the Machine Learning algorithms to combat cyber security threats. Mastercard too have chosen to implement Deep Learning algorithm within their network.

In another recent article in the MIT technology review dated April 2020, [31] explained how hackers were trying to trick Tesla's program into veering into the wrong lane whilst driving. However, Elon Musk's investment in Machine Learning in its cyber security has seen success in its wins in favour of the AI versus hackers according to the review published. Diagram 4 goes on to show that in another study [26] Tesla used Machine Learning to secure Wi-Fi and browser vulnerabilities using 0-day exploits to limit tampering with autonomous vehicles which can be disruptive.

Through these success stories as shown from the diagram above, there is certainly an overlap in the types of methods being used and this lends a hand to the techniques plus algorithms distributed to get the best effective solutions in the market to combat cyber threats through various cyber security software packages. In the next section the study will take a closer look at the role of Machine Learning within the SME industry and how they compare to the uses of its algorithms in SMEs cyber security software packages.

SME and Machine Learning

The target and focus of this study is to understand how SME companies use Machine Learning and AI in their cyber security element of their business and compare that of the technology giants such as Google, Amazon, and Facebook. Having discussed the broader scope of AI leading onto Machine Learning and its categories and algorithms and its uses, it is appropriate to engage in the methodology in order to address the research objective of this paper. The methods of Machine Learning and its algorithms lead into the focus of this study in which SMEs were given the opportunity to make themselves aware of these algorithms that exist within their own cyber security software package. Further the analysis of this study showed the existence of these algorithms such as Neural Networks, Support Vector Machines, Deep Networks and Bayesian. Most of these are cleverly embedded within the software used and one example is Azure Machine Learning which covers Decision Tree, Linear Regression, amongst others identified [32]. The next section goes on to expand on the methodology used in this study and how its findings and analysis were summarised in this paper.

Methodology

A survey using the software Qualtrics [33] was conducted during the period of Friday 26th February 2021 till Wednesday 3rd March 2021. A sample of 30 participants were chosen at random from a selection of UK SMEs ranging from various industries both vertically and horizontally, targeting

management, technical and non-technical expertise. SME participants were asked if they were using any Machine Learning techniques. Upon sending the survey, 20 participants replied to the survey giving the data required for the analysis at a 67% response rate. The survey targeted UK SMEs and presented them with a questionnaire that was developed in Qualtrics. Qualtrics is an experience management software that focuses on building technology to bridge the knowledge gaps through methods of collecting and analysing data. Within Qualtrics a new project was built called "Use of Machine Learning Algorithms in Cyber Security" and twenty-one questions were created to ask the relevant questions and understanding of Machine Learning and its algorithms in the usage within SMEs cyber security packages. Qualtrics itself is powered by AI and Machine Learning in the predictive questions based on knowledge entry of the survey. Participants were contacted via means of email, social media links such as LinkedIn and Facebook and the target audience participants were given less than week to fill in the survey and complete this pilot study. Ethics were applied to state no personal questions were asked and anonymity was maintained unless voluntarily given in a form of an email for future research contact.

Analysis and Findings

The awareness of cyber security within the environment of SMEs in the UK became the subject of this research and the key questions and findings are discussed in this following section. Key questions that were shared were broken into four components:

1) Details of participant and experience
2) Knowledge of Cyber Security and its packages
3) Knowledge of the Machine Algorithms used in the packages
4) Knowledge of the Price indicators of those packages

These components that formed the focus of the study provided the base of the discussion on which the SMEs awareness is questioned. The broad view of the questions that were shared asked the SMEs what software they used for their cyber security package and if these software's had options for Machine Learning techniques. The questions also focused on SME participants understanding of the configuration and algorithms used for these Machine Learning techniques and if they were being used within the SME. The questions also looked at the understanding of the cost of cyber security software package with and without Machine Learning techniques. The next section provides the findings of the response.

As part of the first component, the participant pool were carefully selected based on the targeted audience of UK SMEs. The industries chosen included:

- Engineering, IT and Consultancy
- Healthcare
- Hospitality and Service
- Insurance
- Other

Other referred to a range of industries not covered under the main components above. These were research, distribution, garage services, property, printers, health & safety, estate agencies, retail, logistics and supply chain. Figure 1 below shows the breakdown of the industries as described above.

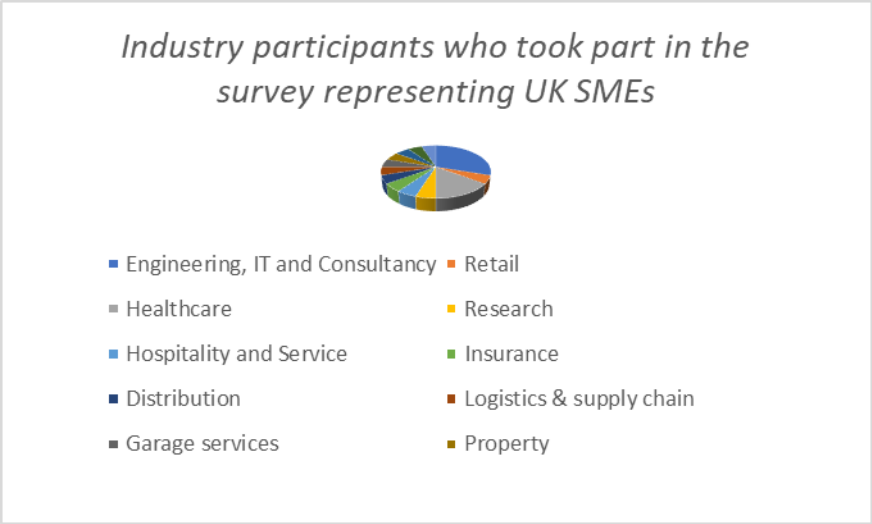

Figure 1: Industry participants who took part in the survey representing UK SMEs

From the participant list surveyed, this paper also looked at the education level of the participants taking the survey. From the Figure 2 below, 25% of participants had a bachelor's degree as a base educational level.

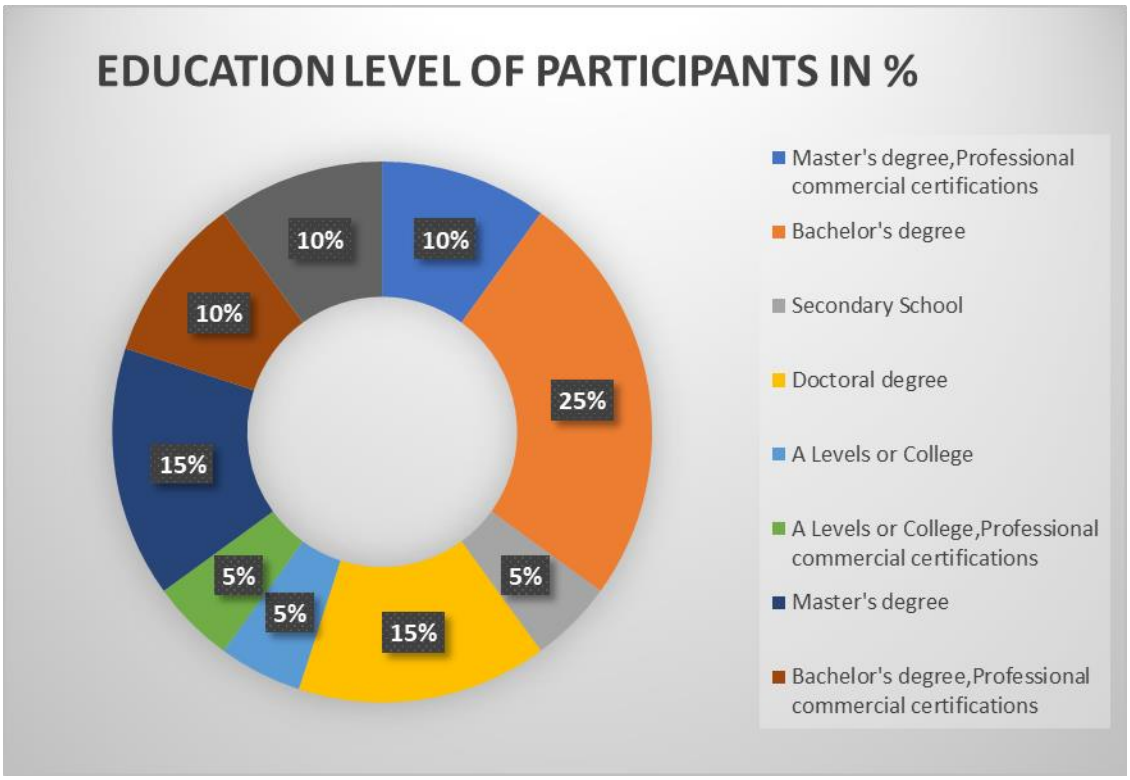

Figure 2: Education level of participants in %

It was also noted that many participants held a university degree plus a professional commercial certification. Figure 3 below shows participants position in the UK SME.

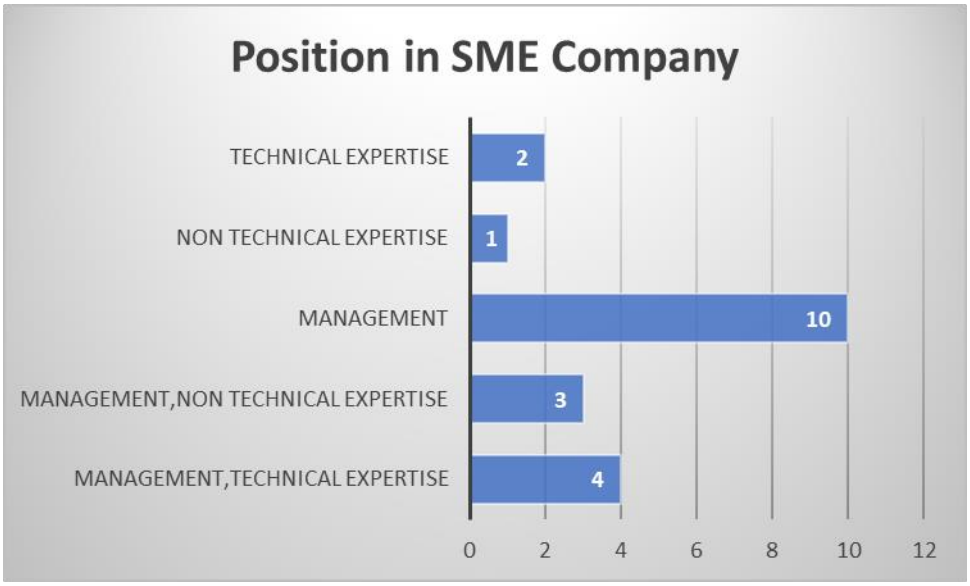

Figure 3: Position in SME Company

Figure 3 shows the majority of the participants were from Management and also coupled with the technical knowledge to run their companies. There were a few selections that were in Management however did not have the technical expertise to hand. Others were exclusively from a technical expertise and one being non-technical.

Figure 4 below shows two components reflecting age and identification of participants in the study. It was clear that there were more males in the field of this study responding than females and the age range covered a higher proportion of participants aged between 36-55.

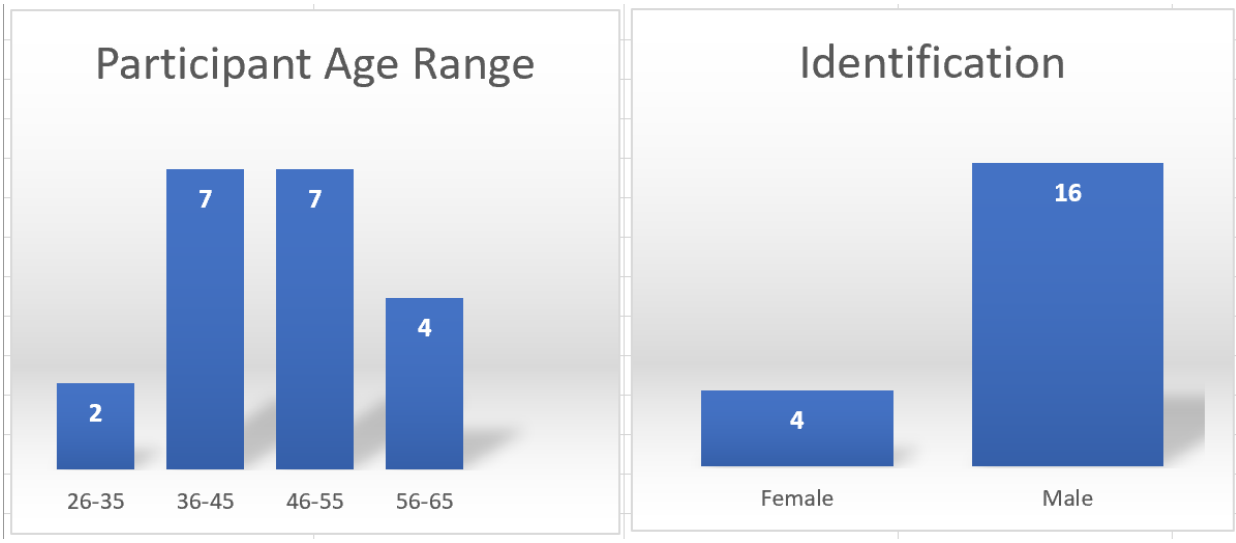

Figure 4: Two components reflecting Age and Identification of Participants

The second component revealed the findings based on the questions surveyed. Figure 5 below askes the question whether SMEs have Cyber Security Software Packages that protects their business from cyber threats.

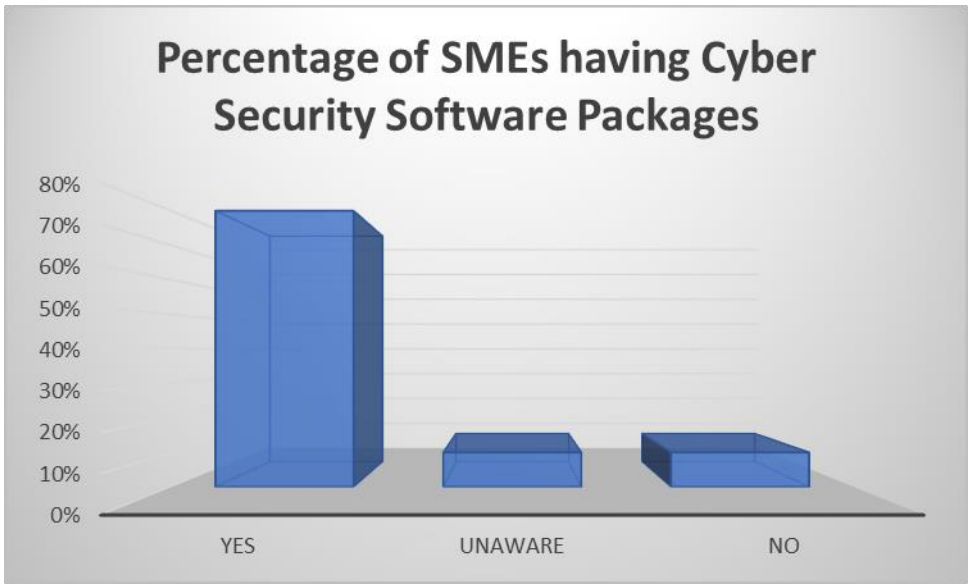

Figure 5: Percentage of SMEs having Cyber Security Software Packages

The results indicate that 80% of SMEs have cyber security software packages in place with a further 10% stating that they did not have these packages installed and 10% stating that were unaware as shown in Figure 5 above.

Based in the above response, the packages identified are shown below in Figure 6. Out of the 20 respondents that replied to the survey, the below gives a breakdown of all the cyber security software packages used.

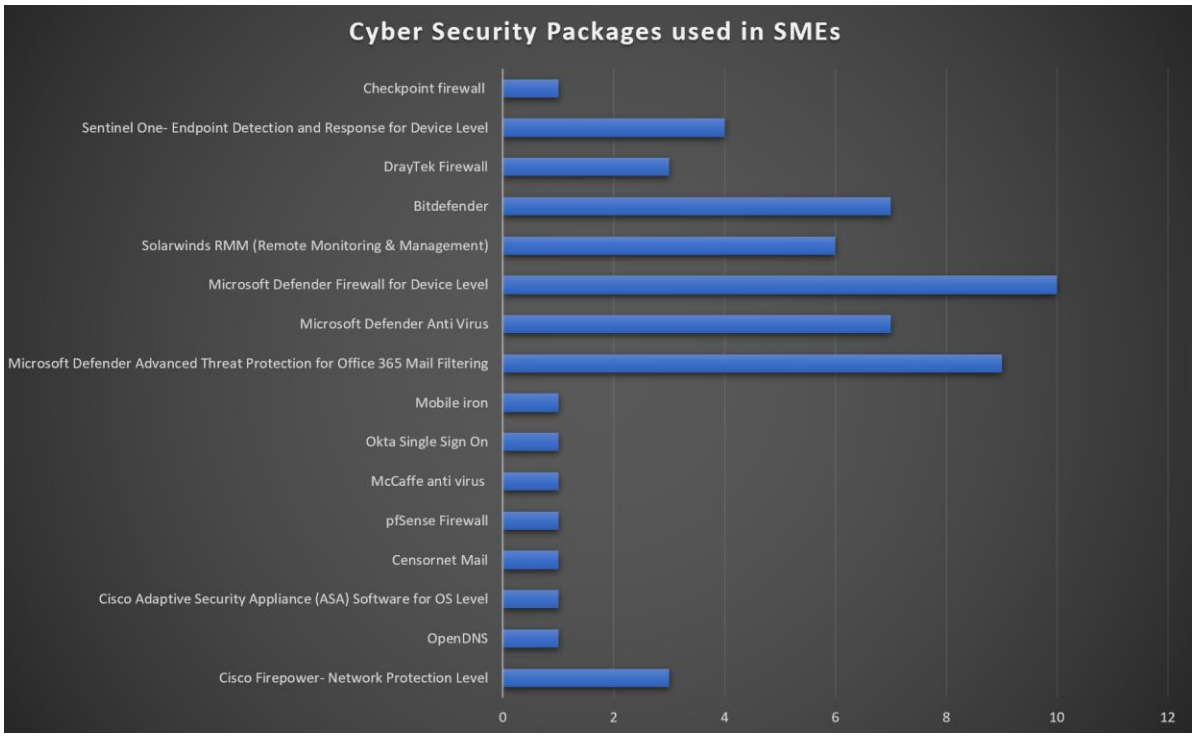

Figure 6: Cyber Security Packages used in SMEs

Based on the above these software packages range from Checkpoint Firewall, SolarWinds, Cisco and Microsoft amongst many others. The next section in Figure 7 below shows SME participant awareness of the existence of Machine Learning in their Cyber Security Software Package in Figure 6.

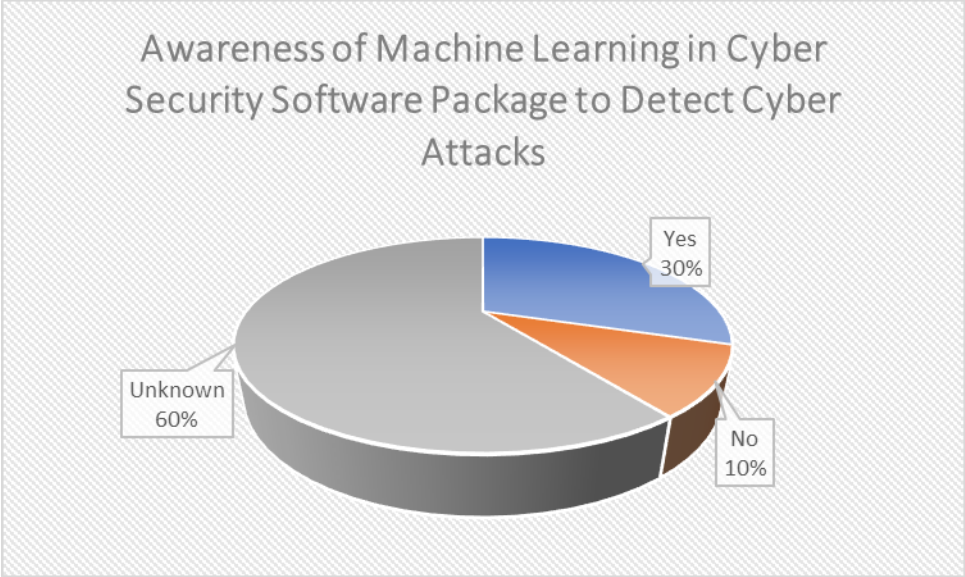

Figure 7: Awareness of Machine Learning in Cyber Security Software Package to Detect Cyber Attacks

The third component showed the proportion of SMEs showing awareness of the existence of Machine Learning in their cyber security software package was 30%. Those who said they did not know was 60% and 10% were a definite "No" in their response to Machine Learning being embedded in their software package.

Referring to the pool that said "Yes" in the 30% of those replied, went on to drill down the types of Machine Learning algorithms that they understood were present in the software packages based on the manuals and specifications provided with the package. Below in Figure 8 it can be seen that various types of algorithms were identified as being part of the Machine Learning that exists within the Cyber Security software Packages defined above in this paper. Amongst them are Neural Networks, Bayesian Model, Support Vector and Deep Network.

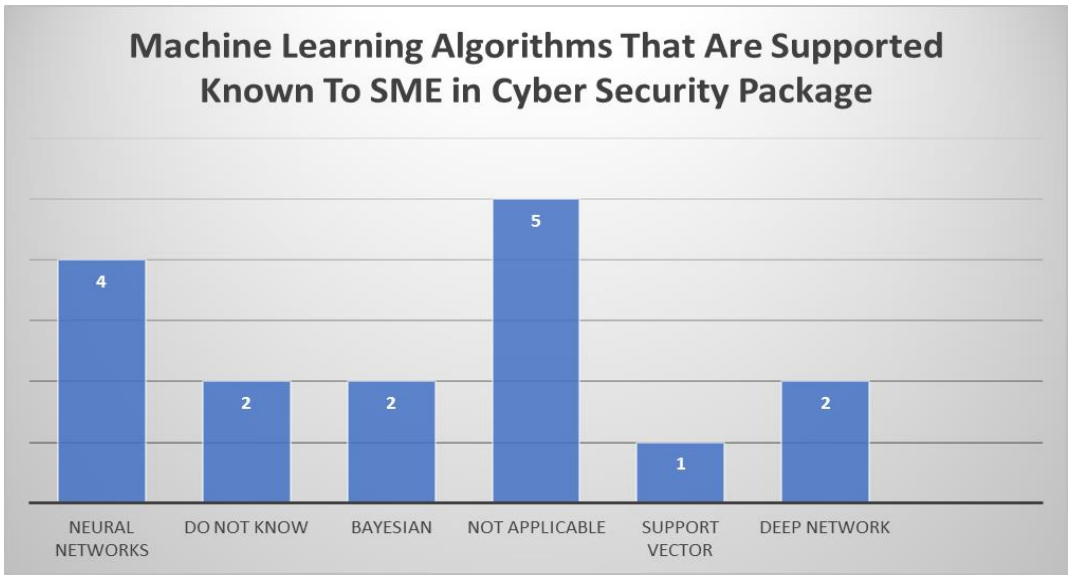

Figure 8: Machine Learning Algorithms That Are Supported Known To SME in Cyber Security Package

From Figure 8 above, there were a few participants from the pool of respondents that either did not know the algorithms or found they were not applicable to the software they were using.

Drilling down further, Figure 9 below shows the actual algorithms that are being used rather than what was available as shown above in Figure 8.

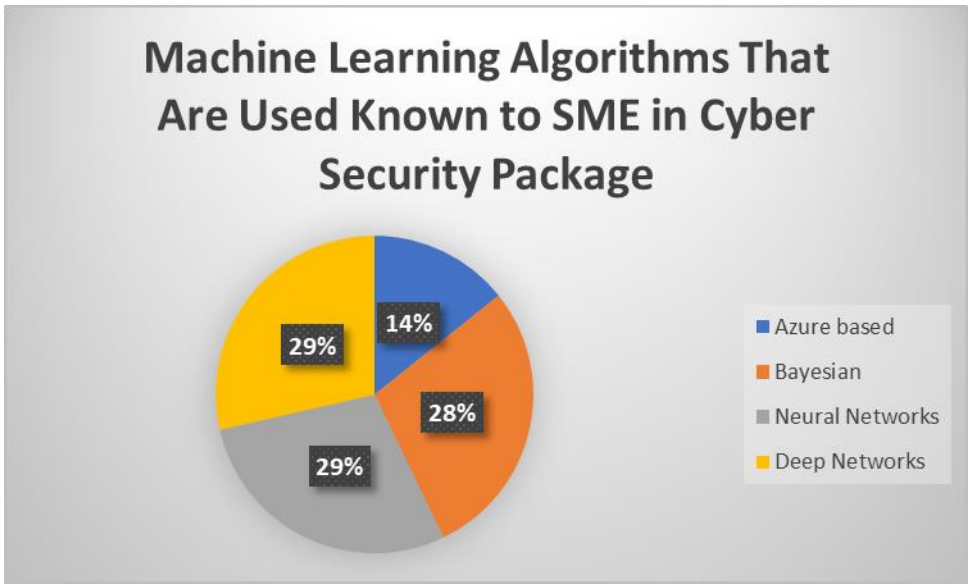

Figure 9: Machine Learning Algorithms That Are Used Known to SME in Cyber Security Package

The chart represents the various algorithms that have been implemented in the use of Machine Learning based on what was purchased by the SMEs and their Cyber Security Software Package. It was clear that in majority of the Cyber Security Software Package, Neural

Networks and Deep Networks were used, Bayesian not far behind and Microsoft own Azure algorithms being a top interest in the growth of Machine Learning.

The final fourth component revealed the awareness of the price attached to Machine Learning in Cyber Security Packages as shown in Figure 10 below

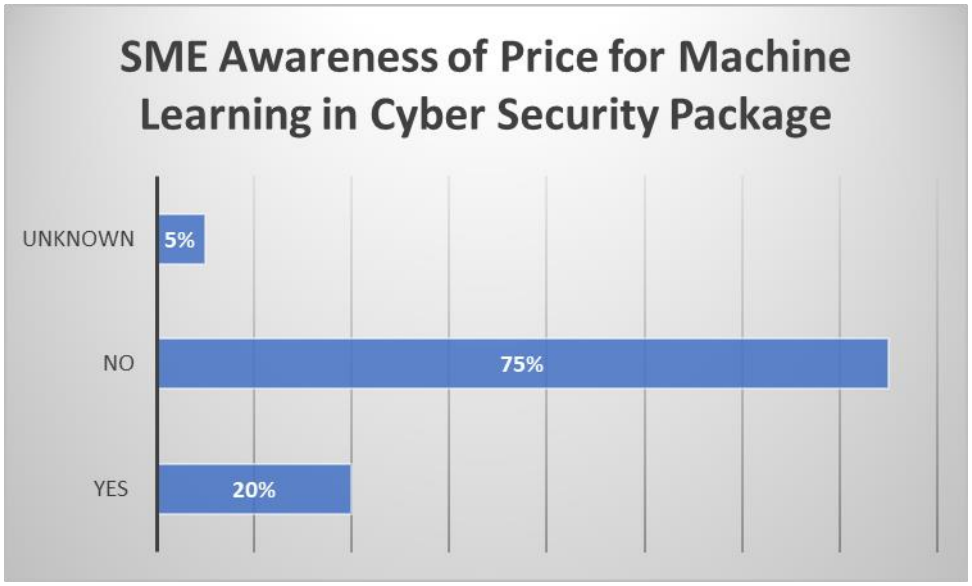

Figure 10: SME Awareness of Price for Machine Learning in Cyber Security Package

Figure 10 shows this awareness and reveals that 75% of the participants surveyed did not know the price for their Machine Learning within their Cyber Security Package. Those participants that were aware made up the 20% of the results with 5% leaving an Unknown response to the price question. From the 20% pool of participants the industry they were in were largely from the Engineering, IT and Consultancy sector with additional Logistics & Supply Chain plus Printing Company. This pool were a mixture of male and females coming from university degree qualifications. These also happened to be from categories listed as Management and Technical Expertise. The 75% pool were represented by yet again a mixture of age and gender however the position and the education varied utilising the other categories listed for education and positions. The unknown only represented 5% of the participant pool who was non-technical although having a position in Management.

Outcome and Conclusion

Based on the analysis and findings, the study revealed that SMEs had the appropriate Cyber Security Packages in place but not necessarily aware of its full potential. Here there was a cross between price of these packages and what the full potential could cost plus the technical barriers within these selected SMEs. It also showed that management and their technical knowledge was not perhaps in depth to the level of Machine Learning and its algorithms. They were familiar of the security and safety these packages gave to their company however they could not identify further the technical aspects of these software's. They were merely recommending these solutions from suppliers of these products. Management wanted to learn more and have a better understanding of AI and Machine Learning especially with the rise in

cyber hacking due to the Covid-19 pandemic that resulted in staff and workers having to work from home leaving data vulnerable to variables within the home networks and security. Some SMEs outsource their IT thus not being able to give a direct and true answer in this survey hence relying on their technical expertise especially during the pandemic. The study also showed that management relied on their IT team's expertise however from thus survey wanted to learn more about cyber security to personally understand how to protect their business. Most decision are made between SME management and IT, and IT seems to be the team to advice on current benefits of new software and how these software's could grow with the business and protect their data. The expertise of the IT team is important in how Machine Learning is used in the future. Some participants did not know that AI and Machine Learning was built into the solution and expressed interest, and some did not care. Some did not think it was high precedence and felt that Machine Learning and cyber threats were not applicable to their business and not relevant to their industry. This is a useful point for policy to take note as awareness in the regulation of cyber security is important especially in the context of SMEs and GDPR. The other point of importance was the costings of these software. Some SMEs judged this to be too high for their operations.

It is apparent that awareness from SMEs in this pool of participants were poor, more work in raising awareness or being informed needs to take place. It could be that small Machine Learning e-learning packages in the form of video or slides targeted at SMEs might improve this awareness emphasising the importance of the subject to both the SMEs and policy. Further research should explore the development of these package with SMEs in mind. Here the study would like to see engagement between governing bodies such as GCHQ and NCSC coupled with GDPR. This is very important as both these governing bodies currently have a critical role in making the UK safe in cyber space. The important policy in the overall framework of GDPR suggests that emerging policy in the context of SME through education, training, awareness should be emphasized.

The results highlight that although Machine Learning is a very effective technique for Cyber Security, their adoption is poor amongst UK SMEs in those sampled in this paper, mainly due to cost and technical expertise. This paper highlights an important gap that can be fulfilled by perhaps more Open-Source and voluntary participants from community to keep the UK SME safe. This article also highlights an important funding gap that could be fulfilled by the government to support SMEs in the form of grants, subsidies, and similar financial assistance through various public sector policies.

Whilst technology giants such a Google, Amazon and Facebook might lead the path in its implementation of Machine Learning and cyber security, it is through these high technology firms that will set precedence and bring awareness at SME level and the importance of Machine Learning in keeping our cyber world safe. This has certainly been heighten even more from the cause and effect of the global Covid-19 pandemic, rising fame to the growing concern that is the cyber pandemic experienced in our time.

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Developing a more innovative ‘Forex’ trading application to shape new and improved trading experiences

Steve Silcox and Fiona Carroll

Abstract

The World is now almost completely online, and with it anything can be achieved using the internet. There is nothing you cannot buy and have delivered to your front door, nor information that cannot be found. It has truly revolutionised retail, banking and entertainment. In banking, or more specifically, in trading stocks and currencies, it is no longer the realm of the city workers in pin-striped suits. The non-trader can now easily go online and trade in these commodities. Nonetheless, most people find the idea of ‘Stocks and Shares’ intimidating, but only through a lack of knowledge or lack of skills to research the subject. In this paper, we perform a systematic literature review to discuss the foreign exchange market (aka Forex) and to identify all publicly available online trading platforms that exist to aid the trader. We analyse these platforms to then develop a more usable tool, called Moving Averages Trading Platform (MATI). This tool uses simple moving averages that calculate the financial data and display it on a user interface (UI). An initial study is undertaken to test the usability and appeal (i.e. trustworthiness) of the tool. The results of the research demonstrates that half of those tested would both use and trust the software developed. However, it is also clear that the design of the UI could be further improved (i.e., more work on the visualisation of the data to lead to more return and repeat usage). Despite the panic that Covid-19 has spread across the globe, the Forex Market is still strong. With some novel technological tools, the authors of this paper feel that there are opportunities for the everyday person to benefit from this.

*Keywords:*Forex Trading; Non-Trader; Moving Averages; Error Detection;
Time Series

Introduction

Foreign exchange is a fast-paced, finance driven market where trillions of dollars are traded per day and large amounts of money can be made or lost. Just like getting your holiday money, foreign exchange simply works by buying one currency with another currency, but on a much larger, global scale. Indeed, similar to getting your holiday money, traders will wait to get the best deal. As prices are changing every second of every day, traders use a variety of mathematical tools, and a sprinkling of knowledge to keep up with the fluctuations of these currencies. In doing so, they hope that they will spot the exact opportunity to make the most profit. These actions play a vital role in the functioning of the economy of a country however the question arises: could the everyday person on the street be able to capitalise on this too? With a basic understanding of computers and how to install software would they want to engage in this fast-paced world of buying and selling? This paper will investigate the foreign exchange market (aka Forex) and some of the current ways to trade, particularly different types of architecture already in mainstream existence. The present initial study will leverage through technology a synergy between humans, and Forex and in doing so aims to provide to the general public a new type of trading platform and a new way to engage with Forex. The paper will describe the design and implementation of an engaging prototype, MATI, and through evaluation answer the research question: Would making trading data easier to understand increase the participation of the non-trader in financial data?

1. Aims and Objectives

The aim of the research is to develop of a simpler more user-friendly application that provides the non-trader with a clear indication of market direction and increase their engagement/ participation with trading data. This paper will document the journey to making this software easy to understand to ensure that it will support the average person to trade in Forex.

To achieve this aim, the research has explored the ways that are currently available to trade? How is this data normally presented? And why is there a belief that Forex trading is difficult? It has

attempted to understand the best way to provide basic information to the non-trader and then selected the appropriate measures used by traders that non-traders will be able to understand and follow. (These formed the basis for the User Interface). The research undertook the design and production of a viable digital trading experience which was evaluated to determined ease of use and if the user felt empowered to trade in Forex.

Critical review

Seng Hansun, a former lecturer and researcher in Indonesia has developed or part-developed the majority of the moving averages cited in this paper (Hansun, 2017). The error detection techniques are credited mostly to him too. All moving averages are simple mathematical formulas that are easy to comprehend and produce varying results commensurate to their equations. The same conditions occur with error detection techniques. The authors found that these produced a positive prediction of 70% of a small random sample test using various timeframes.

Applications that are currently available to use are discussed in depth, these include desktop, web-based and mobile applications. In comparing each platform/company combination, it was found that all platforms provided the same data as the other companies. Importantly no company provided data in the structure this paper proposed.

Human-Engaged Computing (HEC) and the Stock Exchange

Engagement is a very important aspect of any online products, systems, and/or services. As Doherty and Doherty (2019, p.29) state ‘Engaging experiences are built on usable interaction’. Moreover, Human-Engaged Computing (HEC) is about establishing synergised interactions between engaged humans and engaging systems that will enable people to realise their full potential and create a better world (Ren et al., 2019). The aim of this research is to design for an engaging and trustworthy online trading experience where the user not only becomes involved and drawn into experience, but also becomes interested in continual interaction. To achieve this it is important to understand the stock exchange, the following sections aim to give a little more insight into the Forex experience and the techniques that currently exist for use.

What is Forex?

The London Stock Exchange, New York Stock Exchange, Dow Jones et al all deal with companies that have 'floated'. To 'float' a company means that it changes from privately owned to being publicly owned. Companies float on a stock market as a way of raising capital. This floatation is in the form of shares that people can purchase. Some people buy these to become shareholders in the company; others, traders, may use these shares to make a financial profit at a later stage. Commodities are assets like gold and oil that, like a company, can be traded on; prices move based on supply and demand for each commodity, along with how much is available. The Forex markets work on the same principle except people trade in world currencies. Forex is a global market of institutions trading the predominant currencies of the world. The Market is open from Monday morning (starting with Asian markets) and closes on Friday evening (closing with the American markets). Trades occur 24/7 throughout this time. Traders range from large, multinational companies to individual investors. The average daily turnover of trades in the market is averaged at $5.1 trillion per day (for International Settlements, 2016). In much the same way that positive/negative information about a company will alter the price of their share value, Forex prices are affected by factors such as a nation's economy, politics, weather or unforeseen events such as COVID-19.

How does it work?

Currencies are traded in pairs, the value given with the pair is the cost to buy the base currency. For example, GBP/USD 1.3505 (Pound Sterling/US Dollar) indicates £1 would buy $1.3505. If the price is expected to rise, this would be known as "going long". To "go short" would be to sell the Pound with the option to buy it back at a lower price. The rise and fall of currencies in all markets is undetermined and completely random; to paraphrase the book "*The Microstructure Approach to Exchange Rates*" (Lyons, 2001) the author comments on a few days spent alongside a trader friend. The trader regularly produced $1 billion in trades every day with the standard trade being $10 million – no small change. However, even at this level the trader had to ask his friend "What should I do?" signalling that he didn't know which direction the market would go. Experienced traders are able to spot repeatable price action patterns and trade with a degree of certainty, but not all the time.

Not all traders are the same, generally, there are four types:

- Position Trader: Trades for long-term investments of months or even years
- Swing Trader: Trades for a week-long investment
- Day Trader: Will make 2-3 trades per day
- Scalper: Scalpers are fast-acting, get-in-get-out traders, making multiple trades per day.

- *Moving Averages*

Most, if not all, methods used in Forex are time series analysis. These are written to predict the future prices of currency pairings. One of the earliest was SMA, a simple averaging technique; this evolved to Weighted Moving Average (WMA). Exponential Moving Average (EMA) is a type of WMA that was merged to create Weighted Exponential Moving Average (WEMA)(Hansun, 2013, 2014). Furthermore, Double Exponential Smoothing became B-DES and was later merged by Hansun (2016) to become B-WEMA.

In simple terms, moving averages are just a mathematical calculation of previous values of the currency pair and are used to make a prediction on the next value. An example would be a 5-day moving average as shown in Table 1. 15th Jan shall be today (the day we wish to predict), a 5-day count back will calculate data from 8th to 14th (the weekend is not used as the markets are closed). Table 2 gives the same example for the 17th Jan.

Mon	Tue	Wed	Thu	Fri	Sat	Sun
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Table 1: 5-day moving average for 15th Jan 2020.

Mon	Tue	Wed	Thu	Fri	Sat	Sun
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Table 2: 5-day moving average for 16th Jan 2020.

- *Error Detection Techniques*

Along with the various Moving Average methods that can be utilised, there is also a means of comparing the predictions. Hansun (2017) details using both Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE) as a means of error detection (ED) to test that WEMA and B-WEMA produce the same accuracy. Mean Absolute Deviation (MAD) and Mean Root Square Error (MRSE) (or RMSE) are other examples of error detection.

In more detail, error detection is a way for the user to gauge the accuracy of moving average data versus the actual data. Mathematically, the goal for error detection equations are to be as close to zero as possible. EUR/GBP is presented to 5 decimal places, therefore an error detection of 0.00000 is the desired result for every outcome.

- *Mean Absolute Deviation*

MAD is derived from the positive difference between the data point and the MA (based on whichever is used); the results are then totalled and divided by the number of calculations performed. The performance indicator, when using MAD, is how close the number is to zero (Chunhua et al., 2011).

$$MAD = \frac{\sum_{C,S=1}^{n} |C_n - S_n|}{n}$$

Where *C* is the closing price and *S* is the SMA value; *n* is the number of results calculated. MAD can also be referred to as Mean Absolute Error (MAE).

Machine learning and Forex

One type of algorithm used in Forex is SVM which uses Statistical Learning Theory. This is a supervised learning model of machine learning that contains a small sample to research learning rules but also helps to reduce, or eliminate, overfitting (Hui and Wu, 2012). In their research (Hui and Wu, 2012), tested SVM alongside SMA and resistance/support, Kestner & trading range break filters. This research was stock exchange based and an interesting point in the paper was the volume of trades (28.6% in May 2011) that used some sort of computer-based program to complete a transaction (Hui and Wu, 2012). The paper highlights the need for "*software and auxiliary function to be used whilst trading*" (Hui and Wu, 2012). A buy and sell (or sell and buy) action is generally referred to as a trade. Indeed "*34% of the trading volume in the second quarter of 2002 comprises some form of computer-aided trading*" (Ellis and Parbery, 2005).

In fact, SMA can be used to support other classifications. Incorporating a neural network to map news items where positive sentiment had a value of 1 and negative sentiment had a value of -2 (Lauren and Harlili, 2014) were then able to use SMA 33 to prove that positive news items had a positive growth on the JKSE (Jakarta Stock Exchange). Much like Lauren and Harlili (2014) converting news into a positive or negative number, Baasher and Fakhr (2011) used a binary method, coupled with SVM, RBF & MLP machine learning techniques, to predict the direction of the high rate. (Each currency pairing has four daily rates: Open, Closed, High & Low). The aim was not to predict the price, it was to predict the correct direction of the pairing.

One type of Machine Learning is Deep Learning, and within this field are Neural Networks. These too can be used as a tool to predict Forex. For example,
Sespajayadi et al. (2015) combine genetic algorithms with neural networks, with
Root Mean Square Error (RMSE) for error detection, to predict the EUR/USD. Whilst many chose to predict just the close value, Sespajayadi et al. (2015) decided upon predicting all four movements, open, close, high & low. All gave an RMSE of great than 0.001.

What software is already available to use?

There are three platforms that Forex trading is readily available on:

- *5.1. Web-based*

There is a range of software available to trade Forex. The aptly named Forex.com is a web-based program. Along with other types of indicators, it provides a larger range of moving averages such as Arnaud Legoux, Least Squares, Hull, Exponential, Weighted, Smoothed, Simple & Channel. The layout of the user interface (UI) is simple but effective, there is little clutter to distract the user. Howvever, there are a range of indicators to select from and as Figure 1 shows, with just six indicators selected it can be hard to decipher which indicator is which. The six indicators (Moving Average Channel (MAC), two versions of Double Exponential Moving Average (DEMA), a Bollinger Band (a form of double moving average), a Moving Average and an Exponential Moving Average) makes it look unorganised. The Bollinger Band is the upper and lower limits (called envelopes) of the light blue shaded area.

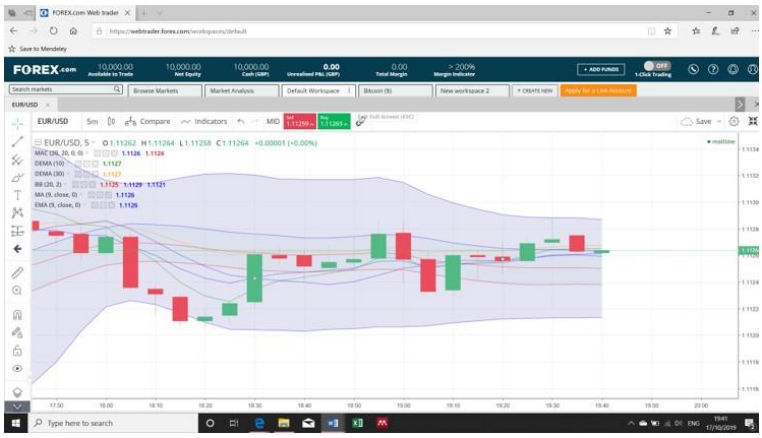

Figure 1: Forex.com.

Another online trading platform is FXTM. This is available from forextime.com. Registration is easy and includes a two-factor authentication on registration, but it seems that this is not needed when logging onto an active account. The website prompts for a lot of personal information that is not required in order to set up a demo account. As well as name, date of birth and address, it also requested an identity document and proof of address. The website displays low ethical qualities and raises questions as to why all the data is required. FXCM.com showing in Figure 2

displays the same moving average indicators as Forex.com and as such demonstrates how easy it can be to become lost in the data. There are, of course, plenty of websites that provide Forex trading: CityIndex.co.uk, Intertrader.com, IG.com, Fondex.co.uk, FxPro.uk, ICMarkets.com and Pepperstone.com. These either, provide the same information and user interface styles as those already discussed or require personal information to open a demo account.

- *Smartphone applications*

Forex.com, despite giving a PC-based platform for Forex trading, gives some foreign exchange rates but focuses more on commodities. Furthermore, there is nothing in its smart application that allows the user to select any indicators.

FXCM too has an application for smartphones. The application opens to a

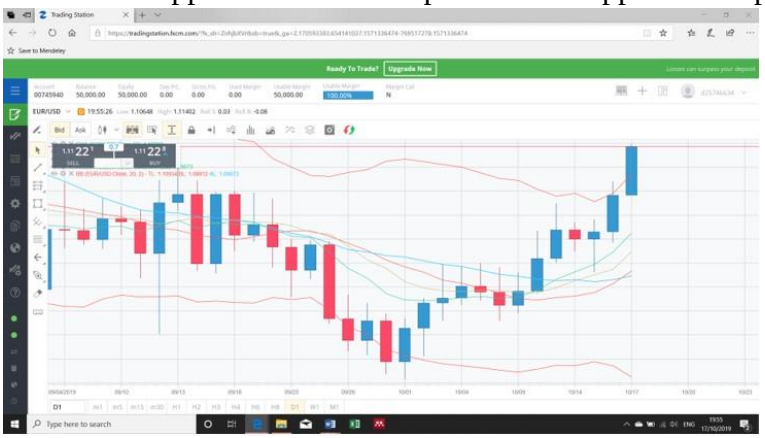

Figure 2: FXCM.com.

blank screen asking the user to accept the terms of agreement. Forex Signals, Figure 3, is not so much a trading application more of an application that informs you of some trading signals. There is no ability to be able to look at the various markets, nor to select a currency pairing.

Trading 212 is a good application for traders, it provides the standard information in the user interface and a range of indicators that the user can overlay onto the currency pairing as we see in Figure 4. The downside of this application, like all web-based platforms, is the inability to understand how to proceed. It is unlikely a non-trader can read these and instinctively know when it is a good time to trade or not.

MetaTrader is the program being used to download the live data within the paper, it has the same functionality as Trading 212; good – but not suitable for the non-trader. Again, there are

plenty more to choose from, some very poor and some really good for the experienced trader. As far as the authors can determine, there is very little available for the non-trader.

- *Downloaded software*

MetaTrader 4 has previously been mentioned as software that can be downloaded to run on a user's desktop or laptop. MetaTrader 4 updated to MT5.

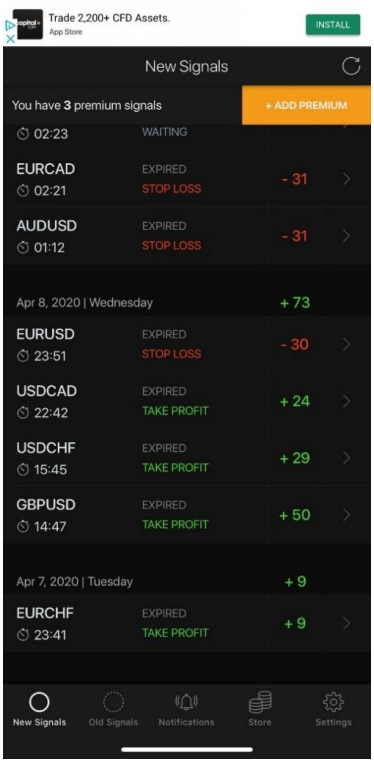

Figure 3: Forex Signals.

MT4 and MT5 use a database called MetaEditor. MetaEditor gives the user the ability to call historic data from its database. MetaEditor uses MetaQuotes Language (MQL) 4 & 5 respectively as its language. MQL is syntactically based on the C language.

cTrader, similar to all the reviews here, gives the same types of information and allows the user to place trades in a demo or a live account. cTrader has a built-in editor; this programming language is cAlgo and allows customised indicators using C#. Social trading is a relatively new idea that gives novices and/or investors a way to earn from Forex trading. It works in two ways:

1. Copy trading – the novice copies the trading patterns from an expert trader. It can be seen as a way to reduce the learning curve from novice to expert. This is also known as Open Book.

2. Mirror trading – when the expert trader executes a trade on their account it automatically executes a trade on the investors account.

Figure 4: Trading 212.

A third aspect of social trading is where traders share their knowledge with other traders. Rather than trading against each other, more so, they are pooling resources and trading against the market. There are a range of platforms that give this experience: eToro, ZuluTrade, Ayondo, Tradeo and Darwinex are to name a view.

MAT1: Why is this application different?

The application, which has been called MATI, moves away from the clutter of the previous screens and provides a numbers-based snapshot of all the current indicators. The other significant difference is that MATI takes all the previous data and then informs the user "If I traded with this data in the last x minutes, I would have been x% accurate." These two differences, which have not been seen in any other FOREX-based platform eliminate the need to understand and digest a

multitude of indicators and trade just on the applications' percentage of correctness over the last x minutes. The design of MATI falls into three broad
categories:

1. Write code to capture data from MetaTrader 5 and export to SQL
2. Tabulate the data within SQL, remove all non-essential data and create Moving Average and Error Detection values
3. Create a GUI in Java and import the MA & ED values

Firstly, this required the production of code to capture data from an online data source: MetaTrader5 and stores this in a database to be called upon when needed. Secondly, it involved the production of code to display a GUI that details the predicted direction of the currency pair based on moving averages, along with a percentage of accuracy for the last prediction. Finally, the production of code was necessary to feed the algorithms with the data needed to be displayed in the GUI.

- *MetaTrader5*

MT5 is a software application provided by MetaQuotes Ltd that allows users to trade in Forex currencies. It provides the user with a range of indicators, oscillators, moving averages and many more mathematical equations that aide the trader. MT5 also contains a sub-program called Meta Editor 5. MT5 operates in the MetaQuotes Language (MQL); a C-based language. MT5 allows the user to customise the MT5 platform for their own trading needs. Using an add-on application called MT5 Data Downloader Tool (MT5DDT), Figure 5, users have the ability to download various currency pairings with multiple timeframes.

- *SQL*

Short for Structured Query Language, SQL is used for databases. A database is essentially a record of records. A company's HR department will have database

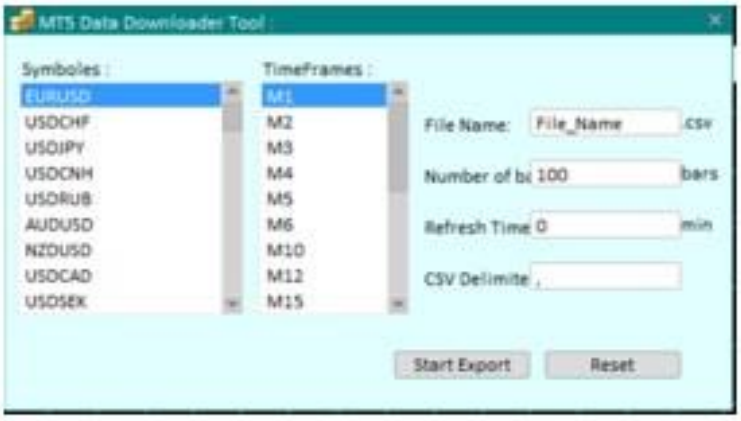

Figure 5: MetaTrader 5 Data Downloader Tool.

of employees, a shop has a database of stock; a library has a database of books. This can easily be stored in a spreadsheet too (e.g. MS Excel) and the majority of us know how Excel works, it is a staple of most people's working lives. It's (mostly) easy to use day-to-day, can be used to calculate columns, rows, averages, sort things alphabetically, and can produce a host of charts and graphs. Excel is also known as a flat-file system – it contains one record per line and does not contain an option to successfully search for a specific type of data. A phone is a good example of a flat-file system. Each new '*line*' contains a new
entry.

Short of producing graphs, SQL does those things too, but much better. This is due to SQL's predominant feature of RDBMS – Relational DataBase Management Systems. A relational database takes the information it contains and splits it into individual tables. Table 3 is the flat-file system, the Excel sheet. It is easy to see there are just two people, yet they consume five lines for their data. By using RDBMS this redundancy of data can be reduced by a process called normalisation. Developed in the early 1970's by Edgar Codd, normalisation allows the data to be transformed into various tables but with the emphasis on maintaining the data and reducing redundancy (EF Codd, 1970).
Each table is linked to another via a 'composite key' such that any table can be called upon to obtain the required data, and only that data.

Order number	First name	Surname	Address	Phone number	Product type	Colour	Size	Cost	Quantity	Total cost
59876	Rebecca	Johnson	49 Drew Road	029 381834	Jeans	Blue	28	£14.99	2	£29.98
59877	Rebecca	Johnson	49 Drew Road	029 381834	Shoes	Brown	6	£12.99	3	£38.97
59878	Rebecca	Johnson	49 Drew Road	029 381834	Jumper	Red	M	£29.99	1	£29.99
59879	Mushtaq	Aqbar	28 Lyttleton Lane	028 282738	Shirt	Blue	M	£33.99	3	£101.97
59880	Mushtaq	Aqbar	28 Lyttleton Lane	028 282738	Socks	White	6	£10.00	2	£20.00

Table 3: Flat-file system akin to MS Excel.

Java

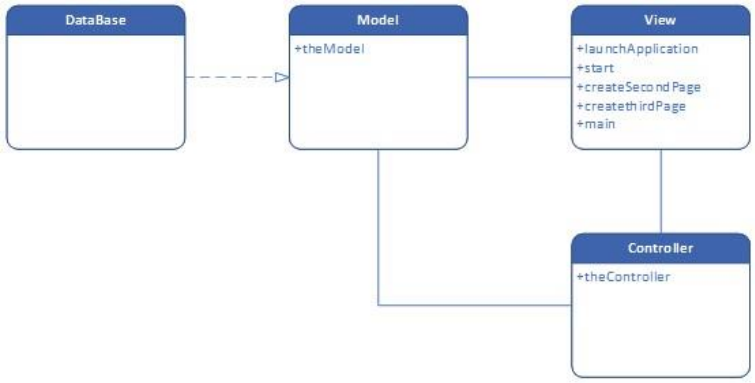

Figure 6: Software design of the three Java classes, with input from the Database.

There are a range of languages, around seven hundred, that are available to code MATI in. HTML, the language of the Web, is extremely versatile due to its ability to work in any operating system. Java was selected purely as personal preference to the authors. Unified Modelling Language is a way to visualise the layout of the code. MATI uses a style called MVC (Model, View, Controller) where each class controls just one aspect of the entire program. The UML diagram in Figure 6 shows the three classes in Java along with the database (indicating where the data is sourced from). The information inside each class are constructors and methods, these are small packets of code that operate unique parts of the overall program. For example, the data that is outputted to MATI should be refreshed periodically, this is carried out by the main method that calls the '*createThirdPage*' method.

- *Final MATI Prototype*

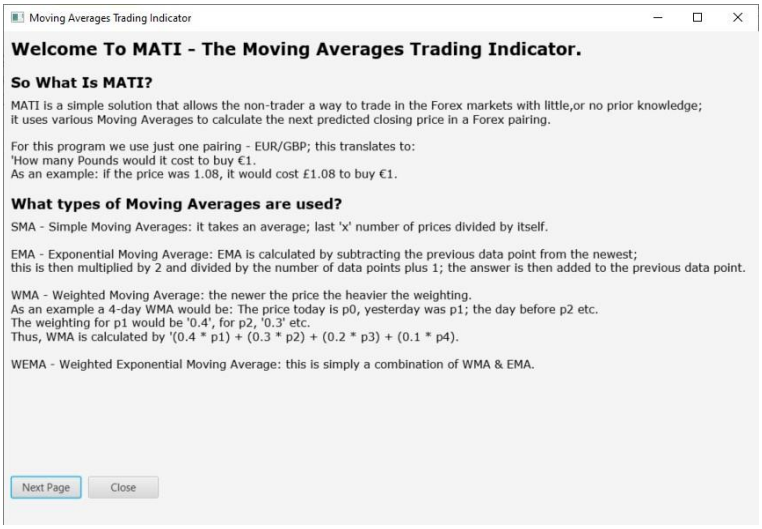

Figure 7: Page 1 of the final version of MATI.

It's a fairly common notion that the human brain performs differently from either side. The left side tends towards the logic and analytical data; the right side towards the more imaginative and visual. That idea holds for traders whose career is based around reading graphs; they have been taught to analyse and they have learnt how to interpret the various peaks, troughs, trends and signals that allow them to be successful. It does not hold though, for the non-trader. The non-trader can easily look at a graph and determine a dominant trend; but this is most likely to lead to a negative profit - they do not actually know what they are looking for. This is one of the reasons for a digital, numerical based approach. MATI takes the data from the graphs and presents it as a snapshot. As MATI is designed to be for scalping, the non-trader does not need to be aware of any other factors. It is quite literally "*get in; make a buck or two; get out*".

The name MATI is an acronym derived from Moving Averages Trading Indicators. With MATI, the idea was to present some of those analytical trends, the moving averages, along with some error detection data, in a numerical format.

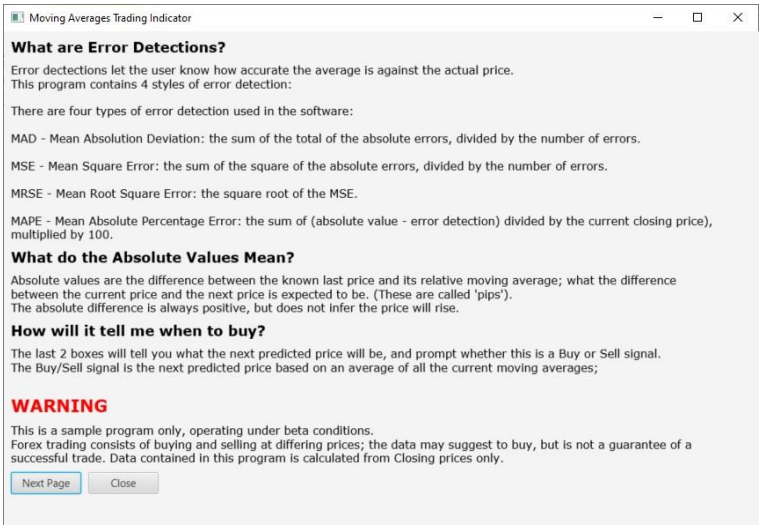

Figure 8: Page 2 of the final version of MATI.

This provides a quantitative data set to the non-trader that should be easier to understand. The end product also instructs the non-trader if it is a good time to trade or not. To achieve this, the final layout of MATI introduced a little colour to highlight certain more important areas. For example, the '*Last Trading Price*' is coloured blue and the '*Buy or Sell*' textbox is coloured green for a buy signal and red for a sell signal. Also, the last and next prices have been placed next to the buy/sell indicator so they are easier to read together. This can be seen in Figure 9. There were two extra pages added to MATI that prefixed the data, Page 1, Figure 7, introduces MATI to the non-trader and explains what the MA's are, Page 2, Figure 8, explains the ED's, absolute values, the buy/sell signals and a warning about the financial aspects of trading in Forex.

Research Design

This study, which took place at Cardiff Met University in April 2020, aims to give some insight into individuals' perception and engagement with the MATI application. Sixty participants from the age of eighteen plus years completed

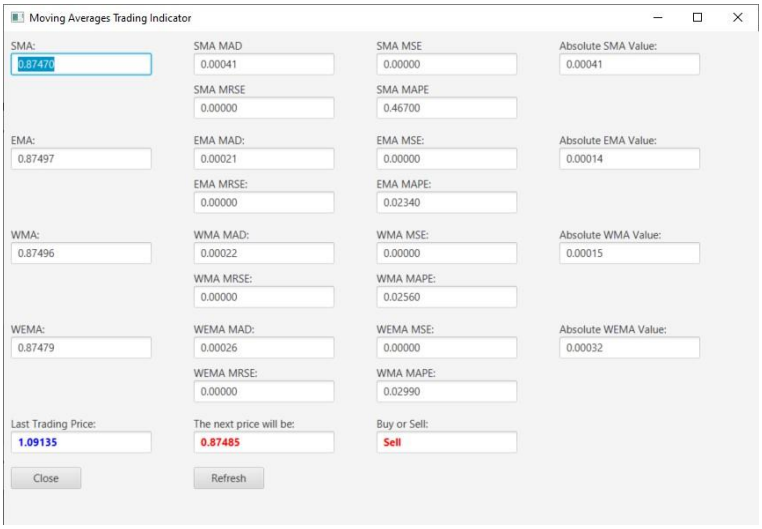

Figure 9: Page 3 of the final version of MATI.

the study. The study was conducted using the Qualtrics online survey software; this paper presents a quantitative and qualitative analysis of the online survey data.

Participants were first asked to interact with MATI for a series of trades, however, due to COVID-19 restrictions this occurred passively via an online video demonstration (Silcox, 2020). A sample set of data, Table 4, taken from MT5, was used to evidence the accuracy of MATI; this was also included in the online demonstration.

	Opened @	TimeFrame	Last Price	SMA	EMA	WMA	WEMA	Next Predicted Price	Buy / Sell	Closed @	Actual Next Price	High	Low	Result
14/04/2020	2120	4 Minute	0.86928	0.86972	0.86927	0.86936	0.86946	0.86945	Buy	2124	0.86940	0.86944	0.86922	Pass
14/04/2020	2124	4 Minute	0.86940	0.86969	0.86933	0.86935	0.86936	0.86943	Buy	2128	0.86930	0.86946	0.86927	Pass
14/04/2020	2128	4 Minute	0.86930	0.86963	0.86936	0.86932	0.86935	0.86941	Buy	2132	0.86923	0.86935	0.86918	Pass
14/04/2020	2132	4 Minute	0.86923	0.86956	0.86927	0.86929	0.86932	0.86936	Buy	2136	0.86907	0.86936	0.86903	Pass
14/04/2020	2136	4 Minute	0.86907	0.86945	0.86917	0.86920	0.86929	0.86928	Buy	2140	0.86919	0.86926	0.86887	Pass
14/04/2020	2140	4 Minute	0.86919	0.86936	0.86912	0.86917	0.86920	0.86921	Buy	2144	0.86931	0.86932	0.86919	Pass
14/04/2020	2144	4 Minute	0.86931	0.86932	0.86924	0.86922	0.86917	0.86924	Sell	2148	0.86941	0.86942	0.86931	No Change
14/04/2020	2245	3 Minute	0.86971	0.86968	0.86964	0.86964	0.86960	0.86964	Sell	2248	0.86978	0.86990	0.86971	No Change
14/04/2020	2248	3 Minute	0.86978	0.86968	0.86973	0.86970	0.86964	0.86969	Sell	2251	0.86980	0.87014	0.86963	Pass
14/04/2020	2251	3 Minute	0.86980	0.86967	0.86979	0.86975	0.86970	0.86973	Sell	2254	0.86973	0.86999	0.86969	Pass
14/04/2020	2254	3 Minute	0.86973	0.86967	0.86977	0.86976	0.86975	0.86974	Buy	2257	0.86989	0.86996	0.86961	Pass
14/04/2020	2257	3 Minute	0.86989	0.86969	0.86979	0.86981	0.86976	0.86976	Sell	2300	0.86944	0.86994	0.86942	Pass
14/04/2020	2300	3 Minute	0.86943	0.86967	0.86971	0.86967	0.86981	0.86972	Buy	2303	0.86968	0.86973	0.86942	Pass
14/04/2020	2303	3 Minute	0.86968	0.86968	0.86954	0.86966	0.86967	0.86964	Sell	2306	0.86985	0.86984	0.86975	Fail
14/04/2020	900	1 Hour	0.86953	0.87119	0.87004	0.87033	0.87054	0.87052	Buy	1000	0.87020	0.87050	0.86828	Pass
14/04/2020	1000	1 Hour	0.87020	0.87093	0.86993	0.86994	0.87033	0.87028	Buy	1100	0.87203	0.87338	0.86929	Pass
14/04/2020	1100	1 Hour	0.87203	0.87093	0.97053	0.87070	0.86994	0.87053	Sell	1200	0.87207	0.87384	0.87207	Fail
14/04/2020	1200	1 Hour	0.87207	0.87095	0.87205	0.87136	0.87070	0.87126	Sell	1300	0.87270	0.87345	0.87135	Pass
14/04/2020	1300	1 Hour	0.87270	0.87110	0.87232	0.87209	0.87136	0.87171	Sell	1400	0.87198	0.87311	0.87156	Pass
14/04/2020	1400	1 Hour	0.87198	0.87114	0.87241	0.87222	0.87206	0.87199	Sell	1500	0.87003	0.87238	0.86973	Pass

Table 4: Sample data of paper trades used to demonstrate MATI.

This was followed by an online questionnaire (comprising eleven quantitative and two qualitative questions) to capture data on their experiences. Participants responses were recorded on the Likert Scale, these responses could be in a form of agreement, likelihood or difficulty. Cardiff Met University Ethics Board approved the experimental procedure and participants

provided online consent for study completion and the academic use of de-identified data. The questionnaire lasted approximately twenty minutes in duration plus ten minutes for the video demonstration.

- *Analysis and Discussion*

In the first two questions, demographic data of the participants was collected. Of the sixty participants who completed the survey, 30% each fell into the ages ranges 18 - 34 years old, 35 - 49 years old & 50 - 64 years old with the remaining 10% being 65+ years old, Figure 10. The male to female ratio returned 36/24%.

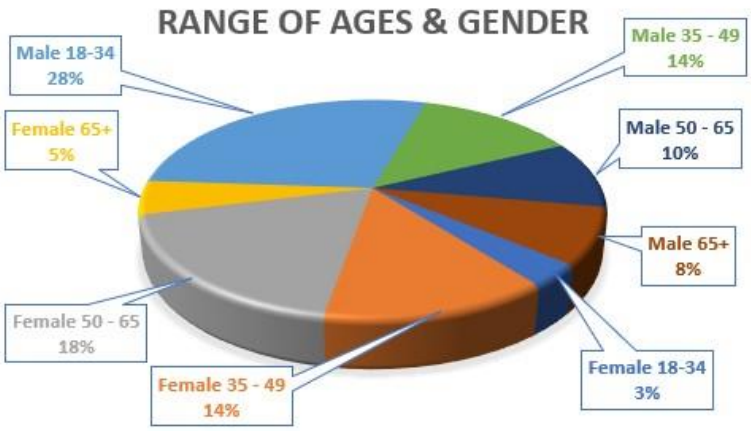

Figure 10: Questions 1 & 2 Responses.

The findings show that slightly more than half, thirty-two participants have no interests in financial trading, which bore out in their knowledge. Table 5 shows that twenty-one of those having ”extremely bad” or ”somewhat bad” knowledge and eight of the thirty-two participants declaring ”neither good nor bad”. Of the twenty-eight participants with an interest, only eight rated themselves to have good knowledge and a further thirteen having neither good nor bad. Thus, seven rated as having bad knowledge.

		Do you have an Interest?		How good is you Knowledge?				
		Yes	No	Extremely Bad	Somewhat Bad	Neither Good nor Bad	Somewhat Good	Extremely Good
Male	18 - 34	11		1	2	6	2	
			6	3	1	1	1	
	35 - 49	6			1	2	3	
			2	1		1		
	50 - 64	3			1	2		
			3	1	1		1	
	65 +	2				1	1	
			3	1	1	1		
Total		22	14	7	7	14	8	
Female	18 - 34	1			1			
			1	1				
	35 - 49	4				2	1	1
			4	2	2			
	50 - 64	1		1				
			10	3	2	5		
	65 +							
			3	2		1		
Total		6	18	9	5	8	1	1
Overall Total		28	32	16	12	22	9	1

Table 5: Participant Interest and Knowledge of Financial Trading.

When reviewing gender, males have more interest at 61% to females at 25%. It also shows the younger the male seems to hold the most interest, although the participant numbers are too small for anything significant. The same correlation was not found for females. From all participants, only one female rated themselves as having an extremely good knowledge.

Age did not appear to be a contributory factor. Qualitatively, the authors wanted to understand why some of the participants had no interest in trading.

For those that answered no to Question 4, we asked them to give a reason. Understandably, some people have no interest in certain activities and at least ten participants responded to having no interest in financial trading. Some commented on the risk whilst others on the perceived difficulty of understanding

it:

- *"I would not know where to start"*, Participant 16
- *"I don't understand it well enough"*, Participant 33
- *"I don't understand it so I've never really looked into it. It sounds a bit like a shady business to me"*, Participant 37
- *"Not really been enticed by it"*, Participant 1
- *"I believe the whole financial system is manipulated to allow only certain companies to succeed."*, Participant 57

- *"FX is very volitile - too easy to lose your shirt"*, Participant 53

These questions asked: *"Have you ever used any trading platforms such as Trading 212, MetaTrader or FXCM?"* and *"How likely would you be to use this software [MATI] if you wanted to trade?"* The latter question was to be answered following the online demonstration. The authors strategically included the earlier question of *"Do you have an interest in any financial trading?"* to see if participants previously negative responses could be changed. The legend for Figure 11 is in 2 parts:

- "Do you have an interest in any financial trading?" Yes or No
- "Have you ever used any trading platforms such as Trading 212, Meta-Trader or FXCM?" Yes or No

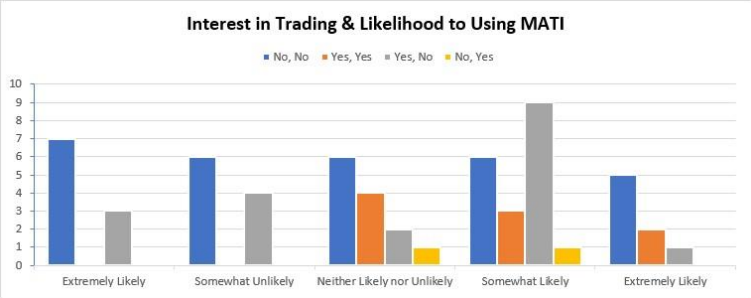

Figure 11: Outcome of participants interest in MATI.

The next part of the study was interested in participants feelings of the actual MATI software. From the findings, we can determine that 45% of participants expressed an interest in using the software after watching the demonstration. Whilst 33% of participants had no interest in using the software and 22% of participants were unsure. Probing the MATI design further, 47% of participants thought that it seemed easy to understand whilst 22% of participants were undecided. Unsurprisingly, those participants with no interest in financial trading found it harder to understand the MATI than those who had an interest. Ultimately, we asked: *"Having seen the relative success of the software, how likely are you to use the software?"*, 50% of participants felt that they were somewhat or extremely likely to use the software. There was 27% of participants who were unsure and 23% that clearly stated no desire in using MATI.

- **Discussion**

The MATI application has proved that a moving averages, digitally based system works. However, there is plenty more that can be incorporated in terms of engaging the general public in continual interaction with the application. As participants noted:

- *"Maybe not all the data being included all the time. Ie an option to see it all or only the ultimate prediction"* Participant X
- Several participants wanted *"More colours..", "...adding some colour would be a nice touch..."* Participant Y
- Most important was: *"...less indicators shown so the non-experienced trade[r]s will not get confused...", "Have the data spread out", "...adding a [legend] for beginners to understand everything by a single look"* Participant Z

In terms of the design, some participants struggled to read the font sizes. Others as we have seen, wanted more colour within the design whilst other participants mentioned the need for an application that was responsive to different screen sizes. As Participant 10 commented: *"The overall user interface is quite limited in it's design. The buttons could use formatting to add some accents to the interface. Adding some colour would be a nice touch. Even a small amount can make all the difference to a person."* Furthermore, the design has only been used on a 17" laptop screen which made it difficult for Participant 31: *"I struggled reading the font size, but probably because I'm using an iPad."* In terms of the quantity and arrangement of data on the screen, some participants felt they needed more information. Whilst other participants clearly needed less. At the very least, the authors of this paper feel that there should be further research into the aesthetic and usability of MATI to ensure the interface is usable and engaging.

- **Conclusion**

This research investigated how mathematical calculations, moving averages, could be presented to an individual in a manner that would aid but also engage them when trading in Forex. The first challenge was the development of an accurate online trading application. This was achieved by automatically sourcing the data from MT5, transforming it into SQL to then create

the MA & ED indicators. This resultant data was then successfully passed to Java, whose code created the interface that became MATI. The second challenge lay in the design and presentation of this data and interface. As we have seen, 50% of participants stated their confidence and trust in using the MATI application.

MATI concentrated on informing the user on the direction the market was trending and was deemed a success if a buy signal resulted in a higher price than the current price, and a sell price resulted in a lower price. However, Forex operates on *spreads* which is the difference between bid and ask prices. Not only does a trader have to contend with the spread, they also have to understand how wide the spread is too. If the currency pairing is trading fast the spread will be small, a few points, however slower moving pairings could result in a far larger spread. Future versions of MATI would have to include buy/sell & spread data to be confident in its next prediction.

Indeed, in order to succeed as a viable piece of professional software, further upgrades to MATI will also include other forms of moving averages and ED's. But also with that, more technical processes like machine learning and/or cobots could be incorporated. Once produced, these can be integrated into MATI as dropdown menus so the user could select only the datasets they require. In conclusion, insights have been gained from this initial study that can contribute to the future development of a more functional yet engaging and trustworthy MATI. It is our conviction that such a development will produce significant benefits to society, especially as more and more people have embraced Forex trading (alternative way to make money) as Covid-19 continues to take their jobs and erodes savings.

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