Advances in Sustainability Science and Technology

Robert J. Howlett
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John R. Littlewood
Marius M. Balas *Editors*

Smart and Sustainable Technology for Resilient Cities and Communities

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Preface

There is a great awareness of the urgent need to eliminate carbon emissions and improve the operational energy efficiency of the built environment to reduce the harmful effects on the ecosystem of human economic development and mitigate climate change reality. This has led to a huge growth in research around the science and technology of sustainable and resilient development. The series 'Advances in Sustainability Science and Technology (ASST)' was created by Springer Nature and KES International to respond to the need for a publication channel for the latest high-quality research on a broad range of sustainability topics.

The rise of the COVID-19 pandemic led researchers around the world to apply themselves to devise measures to alleviate its harmful effects upon society. This included not just clinical researchers, but also those working in areas such as engineering, computer science, and the built environment. In March 2021 KES International, a professional organisation for researchers in high-technology subjects such as artificial intelligence and sustainability, held the 'COVID-19 Challenge International Virtual Summit'. This had the theme 'A Transition to a more Resilient World' and provided the opportunity for those undertaking innovative research on measures in response to the pandemic, to present their work.

After the summit, selected authors were invited to write chapters for a book in the ASST series entitled 'Smart and Sustainable Technology for Resilient Cities and Communities'. The aim was to create a volume of research applicable to the mitigation of the COVID-19 pandemic and furthermore to look beyond it to improve the resilience of society, to make it better able to respond and withstand future disruptive challenges, including both pandemics and increasing problems due to climate change.

The outcome was this book which contains an overview and reports of 21 research investigations from mainly non-medical researchers in universities around the world.

This book is directed to engineers, scientists, researchers, practitioners, academics, and all those who are interested in developing and using sustainability science and technology for the betterment of our planet and humankind.

Thanks are due to the authors and reviewers for their expertise and time. The assistance provided by the support team at KES International and Springer Nature during the development phase of this book is gratefully acknowledged.

Shoreham-by-Sea, UK — Robert J. Howlett
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Prof. Robert J. Howlett is the Executive Chair of KES International, a non-profit organization that facilitates knowledge transfer and the dissemination of research results in areas including intelligent systems, sustainability and knowledge transfer. He is a Visiting Professor at 'Aurel Vlaicu' University of Arad, Romania, and Bournemouth University in the UK. Professor Howlett's technical expertise is in the use of intelligent systems to solve industrial problems. He has been successful in applying artificial intelligence, machine learning and related technologies to sustainability and renewable energy systems; condition monitoring, diagnostic tools and systems; and automotive electronics and engine management systems. His current research work is focused on the use of smart microgrids to achieve reduced energy costs and lower carbon emissions in areas such as housing and protected horticulture.

Prof. Lakhmi C. Jain Ph.D., M.E., B.E. (Hons), Fellow (Engineers Australia), is with Liverpool Hope University, UK and was formerly with the University of Technology Sydney, Australia. Professor Jain founded the KES International for providing a professional community the opportunities for publications, knowledge exchange, cooperation and teaming. Involving around 5,000 researchers drawn from universities and companies worldwide, KES facilitates international cooperation and generates synergy in teaching and research. KES regularly provides networking opportunities for professional community through one of the largest conferences of its kind in the area of KES.

Dr. John R. Littlewood graduated in Building Surveying, holds a Ph.D. in Building Performance Assessment of Zero Heating Housing, and is a Chartered Building Engineer. He is Head of the Sustainable and Resilient Built Environment research group in Cardiff School of Art & Design at Cardiff Metropolitan University (UK). He coordinates three Professional Doctorates in Art & Design, Engineering and Sustainable Built Environment. John's research is industry focused, investigating methods

to optimise the fire safety, production, and thermal performance for existing and new dwellings during the design, manufacture, construction, operation, or during and after retrofit stages. The outcomes of John's research enhance occupant quality of life and increase the environmental sustainability and resilience of the built environment. He has authored and co-authored 155 peer-reviewed publications.

Dr. Marius M. Balas IEEE Senior Member, is a Professor at the Engineering Faculty of Aurel Vlaicu University of Arad, Romania. His research topics are in Systems Engineering, Electronic Circuits, Intelligent and Fuzzy Systems, Adaptive Control, Greenhouses, Modeling and Simulation. He is author of 16 books and book chapters, 120 indexed papers and 7 invention patents. His main contributions: the fuzzy-interpolative systems, the passive greenhouses, the intelligent rooftop greenhouses, the constant time to collision traffic optimization, the rejection of the switching controllers' instability by phase trajectory analysis and the Fermat neuron.

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Chapter 1
Smart and Sustainable Technology for Resilient Cities and Communities—An Overview

Robert J. Howlett and John R. Littlewood

The COVID-19 pandemic has led to enormous human suffering and tragedy with the World Health Organisation estimating the global death toll to have reached nearly five million by late 2021 [1]. It has also had disastrous economic consequences, with the contraction of economies and the likelihood of recession in many parts of the world, which is itself likely to lead to indirect additional loss of life.

However, we should not be too surprised when global disasters occur as they happen regularly and come in many forms. Coronavirus pandemics have occurred regularly before COVID-19, for example the 1918 flu pandemic, SARS, and MERS. Natural disasters also occur regularly, from the Indian Ocean Tsunami of 2004, the Haiti earthquake of 2010 to the Fukushima Daiichi power plant disaster in 2011, following a volcanic eruption under the Pacific Ocean, resulting in a Tsunami. Also, food and water shortages are continuing disasters in many parts of the world, as is the decimation of animal species and reduction in biodiversity. All of this is influenced by the huge challenge of our times: man-made climate change. The European heat wave of 2003, influenced by human activity induced climate change, is not often thought of as a major disaster, but researchers have put the death toll at 70,000 with the observation that "global warming constitutes a new health threat" [2]. Further, the "heat domes" over Northwest Canada and the USA in the summer of 2021 seen as the worst heat wave on record in those parts of the earth saw thousands of deaths where entire conurbations were wiped out by raging fires and external temperatures peaking at mid-50 °C [3, 4].

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There is a need for the development of innovative methodologies and behaviour to enable societies to be more resilient in the face of disasters that occur from time to time, but also the continuing disasters which continue around ourselves due to climate change reality.

When the COVID-19 pandemic struck in 2020, researchers around the world reacted quickly to apply their research to alleviate its harmful effects on humanity [5]. There is the opportunity to learn from this research to help build a better world for society, not just in the short term during the COVID-19 pandemic, but also afterwards if and when it is eradicated. We should be investing in low-to-zero-carbon technologies resilient to future global challenges and disasters, whether natural or man-made.

There needs to be thought leadership on the way that society might evolve in response to current events; for example the dramatic expansion in homeworking and the evolution of smart digital productivity tools to enable this to happen. Cities and rural communities need to evolve to become smarter, more resilient, and self-sufficient.

This book contains this introduction (Chapter 1) and 21 subsequent chapters, divided into four parts. Chapters are from a range of countries and are on a range of topics. Many of the chapters describe research aiming to combat the spread or effects of COVID-19 but containing lessons to be considered for future. In other chapters, the research is on topics that have the potential to improve the resilience of society.

1 Part I: "Changes in Work Practices and Employability in Response to the COVID-19 Pandemic"

This part of the book contains five chapters describing research into improved employability skills and work-integrated learning, digital transformation of small-to-medium enterprises (SMEs), urban mobility, and air quality in the workplace.

Chapter 2, "Examining Pedagogical Approaches in Developing Employability Skills in the Wake of the COVID-19 Pandemic", describes research investigating the various approaches to teaching and learning that can be employed by institutions of higher education to develop employability skills among built-environment students in response to the COVID-19 pandemic. The study found that multidisciplinary teaching approaches, work-integrated learning, and placement opportunities made the most significant contributions to developing graduates' employability. The authors concluded that adoption of these approaches would help make graduates more academically able and also equip them to more easily fit into new work paradigms evolving out of the COVID-19 pandemic and future disruptions.

Chapter 3, "Relating Work-Integrated Learning to Employability Skills in the Post-COVID-19 Era", considers the place of work-integrated learning as higher education institutions around the world reshape their curricula attempting to alleviate

the disruption due to the COVID-19 pandemic. The authors make a case for universities adopting a more innovative approach to ensure that work-integrated learning is successfully employed because of the benefits to students, despite the challenges inherent in the approach.

Chapter 4, "Opportunities and Barriers of Digitization in the COVID-19 Crisis for SMEs", describes work on digital transformation in small companies, which has been a key driver of business model development for a number of years. The study examined the problems and opportunities of integrating digital technology into small-to-medium enterprises (SMEs) that are particularly affected by external factors, including the COVID-19 pandemic.

Chapter 5, "New Urban Mobility Strategies After the COVID-19 Pandemic", is on the subject of an investigation into the measures relating to urban mobility, conducted in various cities of the world, in response to the COVID-19 crisis. The project, which involved cities from Europe and North and South America, evaluated which measures had been the most effective, verifying their effects in both the short and long term.

Chapter 6, "Integration of Indoor Air Quality Concerns in Educational Community Through Collaborative Framework of Campus Bizia Lab of the University of the Basque Country", outlines a research project to monitor and analyse the indoor air quality of several educational facilities in the Gipuzkoa Campus of the University of the Basque Country (UPV/EHU). It is well recognised that good ventilation can reduce the spread of COVID-19 indoors, while poor quality air can increase it. This study examined indoor air quality in several types of classrooms and offices with different characteristics in order to assess the performance of each one of them.

2 Part II: "Smart Techniques for Monitoring the COVID-19 Pandemic and Forecasting Its Course"

This part of the book contains seven chapters. It describes research involving various intelligent, statistical, and advanced sensory techniques in modelling, forecasting, diagnosis, and risk prediction applicable to the COVID-19 pandemic, and beyond it.

Chapter 7, "An Overview of Methods for Control and Estimation of Capacity in COVID-19 Pandemic from Point Cloud and Imagery Data", looks at the way sensing technologies can be applied in monitoring and dealing with the COVID-19 pandemic. The chapter reviews sensing techniques from point cloud and imagery data related to population control and estimation of the capacity, people counting, biometric identification, monitoring of activities, distance measurement, and 3D modelling. The chapter presents current techniques and the algorithms most often used. The merits and disadvantages of point cloud data and imagery and current trends are reviewed.

Chapter 8, "Modeling and Evaluating the Impact of Social Restrictions on the Spread of COVID-19 Using Machine Learning", reports on an investigation into the effect of social restrictions imposed in response to the COVID-19 pandemic. Included are restrictions on schools, workplaces, public events, gatherings, internal and international flights, brought in to control the spread of the virus. Three machine learning models were applied to simulate the number of infected cases per day under different levels of restrictions. Different scenarios of social restrictions were simulated to study the impact of decisions on social restrictions and imposing more strict ones.

Chapter 9, "Forecasting the COVID-19 Spread in Iran, Italy and Mexico Using Novel Nonlinear Autoregressive Neural Network and ARIMA-Based Hybrid Models", presents an analysis of single- and two-wave COVID-19 outbreaks using novel hybrid machine learning and statistical models to simulate and forecast the spread of the infection. For this purpose, historical cumulative numbers of confirmed cases for three countries were used. The performance of the techniques under different conditions was analysed and results and conclusions presented.

Chapter 10, "Spatial Statistics Models for COVID-19 Data Under Geostatistical Methods", describes techniques that can be applied to model distributions of pandemic infection. Geostatistics techniques are explained as a way of quantifying spatial uncertainty, and statistics are applicable to allow probability densities to be employed. Illustration of the spatial modelling based on coordinates considering the epicentres of COVID-19 virus in a small region is considered. Hence, a range of techniques is presented that can be used in the numerical analysis of COVID-19 data.

Chapter 11, "Intelligent Multi-sensor System for Remote Detection of COVID-19", presents the development of a novel multi-sensor method of identifying COVID-19 at a distance. This system applies the principle of multi-sensor data fusion to provide a robust, precise, and complementary analysis of these symptoms to tell whether or not an individual is a carrier of COVID-19 disease. The authors report that the system, designed to be used in public venues, can also be adapted as a useful means of early detection of many other diseases.

Chapter 12 "A Comparative Study of Deep-Learning Models for COVID-19 Diagnosis Based on X-Ray Images", reports on a project to test and compare different deep learning algorithms on a dataset consisting of a large number of digital COVID-19 X-ray images. The motivation is to find an alternative to the reverse transcription polymerase chain reaction (RT-PCR) kits, widely regarded as the best available. The accuracy of RT-PCR is not 100%, it takes a few hours to deliver the test results, and there has been a world shortage of the kits. The authors report developments in their quest to develop an alternative to the RT-PCR test that is not subject to the same disadvantages.

Chapter 13, "Fuzzy Cognitive Maps Applied in Determining the Contagion Risk Level of SARS-COV-2 Based on Validated Knowledge in the Scientific Community", describes research that aims to devise a smart tool to estimate the risk of an individual becoming infected with COVID-19 based on their behaviour. The technique uses a fuzzy cognitive map intelligent paradigm to model data provided from pre-existing

medical research and link behaviour to risk. The authors claim a number of benefits from the tool, including providing information to enable individuals to change their behaviour to mitigate their contagion risk.

3 Part III: "Changes in Teaching and Learning Practices in Response to COVID-19"

This part of the book contains four chapters on subjects related to pedagogic evolution made necessary by the pandemic, including experiences of moving to e-learning, new online training methods, and human factors associated with online learning.

Chapter 14, "Education After COVID-19", is based on the authors' experiences of the changes to pedagogic practice necessitated by the pandemic. Education has been very heavily affected by the COVID-19 pandemic, with delivery moving almost entirely to online form during lockdowns, and often for some time after. While experience has shown some features of pre-COVID-19 educational practice to be out-dated, person-to-person contact is essential for many aspects of the education process. The authors reflect on the past, present, and future of education, what they have learned from the new teaching methods adopted in response to the pandemic, and what beneficial changes can be carried forward into future teaching and learning.

Chapter 15, "Equipping European Higher Education Teachers for Successful and Sustainable E-Learning with Home Remote Work", reports on an analysis of the reaction of higher education to the COVID-19 pandemic. This will enable the lessons learned to be implemented during a possible future crisis.

The authors report on a combined study based on a literature review and a specific survey to higher education teachers in Europe. The study is reported to have provided consistent results to indicate how teachers should be trained and supported for the future.

Chapter 16, "Fully Online Project-Based Learning of Software Development During the COVID-19 Pandemic", contains the authors' reflections on their experiences of delivering software engineering training online during the pandemic. The authors state that they have many years' experience of using project-based learning to develop software education. The COVID-19 pandemic led to this being applied to develop fully online teaching during the 2020 academic year using the process and software engineering environment they developed. This is a combination of a software repository and an online meeting system. Having evaluated this environment through students feedback, they report it to be well suited to fully online remote project-based learning.

Chapter 17, "A Tale of Two Zones: Pandemic ERT Evaluation", describes an analysis of emergency remote teaching (ERT) during the COVID-19 pandemic. During the COVID-19 pandemic, many educational institutes switched from conventional teaching to all online classes. Few institutes were well prepared for this change, and

some faced greater problems than others owing to deficiencies in technology infrastructure. Furthermore, differences were identified between teachers' and students' attitudes to online teaching. These issues formed the basis for the analysis described in this chapter, leading to the identification of opportunities for improvement.

4 Part IV: "Adapting for Improved Resilience in an Uncertain Future" Contains Six Chapters

This part of the volume contains six chapters on topics which can contribute to improved resilience in cities and communities. Topics include coping with change and uncertainty in the built environment, improved resilience in the power system, food supply security, improving resistance to infection, and sustainable low-temperature refrigeration.

Chapter 18, "Anticipating and Preparing for Future Change and Uncertainty: Building Adaptive Pathways", presents an investigation into the nature of future disruptive change and its implications for improving the resilience of buildings. A structured approach is proposed to prepare for, and respond to, change in a proactive, structured way. This methodology is called building adaptive pathways and is illustrated and tested through application to a case study. Findings indicate that methodology provides useful insights on how change and uncertainty can be addressed in built environments and recommends that further work on the approach be undertaken.

Chapter 19, "A Health-Energy Nexus Perspective for Virtual Power Plants: Power Systems Resiliency and Pandemic Uncertainty Challenges", introduces measures to change the power generation and distribution system with the aim of providing improved resilience. The chapter discusses the link between health and energy and the way in which the two are related. The opportunities and challenges presented by the interaction between health and energy are presented, and ways to address the changes in the power systems resiliency due to pandemic conditions are discussed.

Chapter 20, "A Sustainable Nutritional Behavior in the Era of Climate Changes", contains a discussion on the topic of food supply security during disruptions occurring due to climate change and other unforeseen events. The chapter presents the view that the earth's ecosystem is tightly coupled, and different elements are inherently linked. Food supply, the availability of water for drinking and crops, and disease vectors such as COVID-19 are all inter-related to energy availability and consumption and climate change.

The chapter concludes with a number of suggestions for future developments to help improve the resilience of the food supply, including that environmental considerations should be inherent in any future innovations.

Chapter 21, "The Development of a Smart Tunable Full-Spectrum LED Lighting Technology Which May Prevent and Treat COVID-19 Infections, for Society's Resilience and Quality of Life", introduces the concept that lighting with a spectrum that results in increased vitamin-D production in the human body may be beneficial

in combatting COVID-19 and have other health advantages. The research aims to develop a sustainable full-spectrum lighting system using light emitting diode technology to provide a similar colour balance and intensity as daylight in buildings. This will result in increased vitamin-D production in the body, which has been shown to be beneficial for infection resistance in general, including resistance to COVID-19.

Chapter 22, "Energy Efficient Technologies for Ultra-Low Temperature Refrigeration", describes work on the ultra-low-temperature refrigeration technology that is required for the storage of some vaccines. New vaccines have been developed in response to the current COVID-19 pandemic, and some of these require ultra-low-temperature refrigeration (at −80 °C). The technology is not mature, and the energy performance is often low because heat pump efficiency is poor with the large gap between source and sink temperature. There are also challenges associated with refrigerants and lubricating oils. This chapter presents the main characteristics of several applicable refrigeration technologies, ways of overcoming the challenges inherent in using them, and future directions for sustainable ultra-low-temperature refrigeration.

References

1. World Health Organisation. https://covid19.who.int/. Accessed 13 Oct 2021
2. Robine J-M, Cheung SLK, Le Roy S, Van Oyen H, Griffiths C, Michel J-P, Herrmann FR (2008) Death toll exceeded 70,000 in Europe during the summer of 2003. CR Biol 331(2):171–178
3. Reuters (2021) Death's surge in U.S. and Canada from worst heatwave on record. https://www.reuters.com/world/americas/dire-fire-warnings-issued-wake-record-heatwave-canada-us-2021-06-30/. Accessed 20 Oct 2021
4. Vaughan A (2021) The heat is on out west. New Scientist, 10 July 2021, vol 250, issue 3342, pp 10–11. https://www.sciencedirect.com/science/article/abs/pii/S0262407921011696. Accessed 20 Oct 2021
5. Chakrabortya I, Maity P (2020) COVID-19 outbreak: migration, effects on society, global environment and prevention. Sci Total Environ 728:138882 (1 August 2020). https://www.sciencedirect.com/science/article/abs/pii/S0048969720323998. Accessed 20 Oct 2021

Part I
Changes in Work Practices and Employability in Response to the Covid-19 Pandemic

Chapter 2
Examining Pedagogical Approaches in Developing Employability Skills in the Wake of the COVID-19 Pandemic

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Abstract The construction industry today and its employers are gradually coming to terms with the fact that its activities and processes require fully equipped graduates who are furnished with the right skills to succeed after graduation. However, with the continuously evolving nature of the industry coupled with the COVID-19 pandemic, the pressure on higher education to review and revamp its existing curricula has intensified in recent times. The process of developing employability skills among students can be reflected in the pedagogical approaches employed by institutions of higher learning. This research aims to determine the various pedagogical approaches that can be employed by institutions of higher learning to develop employability skills among built-environment students as the world grapples with the after-effect of the COVID-19 pandemic. A qualitative Delphi approach was adopted to validate these approaches. Fourteen experts completed a two-stage iterative Delphi study process and reached a consensus on all 16 approaches identified. This study found that multidisciplinary teaching approaches, work-integrated learning, and placement opportunities are the most significant approaches in developing employability skills among students. It is recommended that universities across South Africa and beyond continue to ensure the inclusion of these approaches into their existing curricula to not only produce graduates who are academically sound but also produce graduates who will fit easily into the 'new normal' prompted by both the COVID-19 pandemic and the Fourth Industrial Revolution (4IR).

Keywords Active learning · Built environment · Construction industry · COVID-19 · Employability · Pedagogy · Skills

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1 Introduction

The present-day construction industry plays a pivotal role in every economy globally. Its role in the achievement of socio-economic development goals and provision of local amenities, employment, and infrastructural development is encouraged through its numerous activities. These activities which range from the construction of highways, dams, bridges, structures, canals among others are strong forces that act as a catalyst for the achievement of infrastructural development in our modern-day economy. One of the characteristics of the construction industry is the mobilization and utilization of both human and material resources in boosting economic efficiency in areas such as infrastructural development, job creation, and sustainability [14]. However, the construction industry is faced with its challenges which arise as a result of the influx of built-environment graduates who are not fully equipped with the right skills [16]. This further implies that the construction sector is heavily reliant on skilled professionals for its functions in infrastructural development, maintenance, and all construction-related tasks. The construction profession, like other professions, possesses high principles about professional ethics, service, and practice. These rules of ethics, therefore, increase the need for graduates with industry-ready traits and skills to function effectively.

Considering the above characteristics of the construction industry which highlights its dynamism and increasing demands, it, therefore, implies that present-day graduates are required to be well educated and fortified with a wide array of skills (academic and non-academic) to address arising and existing industry problems Aliu and Aigbavboa [10]. In fact, due to the advent of the Fourth Industrial Revolution (4IR) and the pandemic-induced changes to the educational system, employers have taken the search for competent and skilled graduates to a whole new level. Aside from been academically sound, the industry now requires graduates to be sufficiently furnished with the relevant skills, abilities, and competencies to fit into the world of work after graduation. Industry employers now place premium value on graduates who can exhibit confidence in communicating effectively; work as part of a team when necessary; possess good ethics; think critically; show a willingness to learn; display flexibility and adaptability; possess analytical skills; understand the dynamics of information and communication technology (ICT skills); possess problem-solving skills among many others [7, 11]. These required skills have placed significant pressure on universities across the world to review and revamp their existing curricula to meet industry needs. It is against this backdrop that this research determines the pedagogical approaches that can be employed by universities globally to develop employability skills among built-environment students as the world embraces 4IR technologies and grapple with the aftermaths of the pandemic. It is worthy to note that the educational landscape has been greatly impacted as a result of COVID-19 which has seen a sudden transition to online pedagogy [44]. Firstly, a large number of academic activities including conferences and teaching activities were canceled and postponed [43], then a few months later, universities around the world began the adoption of technological applications to execute their academic activities. Some of these

tools includes Zoom, Skype, Microsoft Teams, WhatsApp among several others. This new technologically driven paradigm altered the existing ways of teaching and learning with a new dimension of pedagogy taking center stage.

This study was conducted in South Africa and its objectives align with one of the nation's long-term National Development Plan (NDP) 2030, which seeks to develop the skills, knowledge, and capabilities of its citizens through the provision of quality education across all levels. This policy document was drafted in 2012 by the National Planning Commission. This mandate also resonates with the Sustainable Development Goals (SDGs) proposed by the United Nations which plans to ensure quality and inclusive education for all by 2030. In achieving the objectives of this study, a qualitative Delphi approach was adopted to validate these pedagogical approaches as universities across South Africa and beyond embraces the dynamics of the 'new normal'.

2 Review of Literature

2.1 The Era of the 'New Normal'

As the world continues to grapple with the adverse impact of the COVID-19 pandemic, there have been increased uncertainties in several aspects of global economies, and the educational sector is one of them [44]. In a bid to curb the spread of the coronavirus disease, several educational institutions across the world stopped in-person lectures (contact meetings) over a year ago. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), educational institutions in more than 185 countries around the world were shut down at the end of April 2020 [4]. That meant roughly 74% of learners worldwide were affected by the shutdown, which prompted a new approach in the teaching and learning process. Currently, most educational institutions globally have adopted a remote learning (online learning or distance learning) approach to combat the spread of the virus, in what many now refer to as education in the 'new normal'. However, there are some dynamics with this new mode of learning [15]. Firstly, there are concerns that students may have to spend less time during the learning process when compared to physical classroom settings [38]. Secondly, there are also concerns that students are more prone to stress and anxiety during remote learning which may affect their ability to thrive in their academic work [38]. Thirdly, the lack of physical contact with their peers and educators (lecturers) may lead to decreased motivation to engage in learning activities [44]. Fourthly, students from disadvantaged backgrounds will struggle with accessing digital resources such as laptops, internet connections, and scanners among others [44]. More so, the switch from offline to online learning is likely to affect the occurrence of certain higher education activities such as supervised industrial work experience schemes for built-environment students, laboratory experiments [12]. These dynamics have changed the pedagogical landscape and

universities across the world have been compelled to revamp and restructure their academic activities to align with the current climate of the pandemic-driven world (new normal). This also places significant pressure on higher education to develop innovative pedagogical approaches to develop employability skills among students as the world grapples with the effect of the pandemic.

2.2 Understanding the Concept of Pedagogy

While this research aims to determine pedagogical approaches that can develop employability skills in the era of the 'new normal', it is pertinent to understand the meaning of the overarching term—pedagogy. Several researchers have described the concept as an activity or group of activities that result in positive skill outcomes for learners. According to Watkins and Mortimore [55], pedagogy is described as 'any conscious activity by one person designed to enhance learning in another'. Similarly, pedagogy is a 'sustained process whereby someone acquires new forms or develops existing forms of conduct, knowledge, practice, and criteria from somebody or something deemed to be an appropriate provider and evaluator' [20]. The definition by Alexander [6] states that 'teaching is an act while pedagogy is both act and discourse'. This definition suggests that pedagogy is a broad spectrum that encompasses the following characteristics of the educator (teacher): ideas, knowledge, and attitudes, understanding of the curriculum; understanding of the learning outcomes required; and student's limitations during the teaching and learning process [6]. Based on the preceding definitions, the essential goal of pedagogy is to develop learning among students and ultimately their employability skills. Hence, this study adopts the definition by Westbrook et al. [56] which describes effective pedagogy as 'those teaching and learning activities which make some observable change in students, leading to greater engagement and understanding and/or a measurable impact on student learning' [56]. Furthermore, it is important to note that for the sake of this research, 'pedagogy' is different from 'teaching practices'. According to Alexander [6] and Thoonen et al. [54], teaching practices are specific and physical actions that occur during the training process to further stimulate the understanding of students. Teaching practices include some of the following: the communicative skills of the educator including giving explanations and instructions, citing examples, asking questions, elaborating on ideas, and accepting responses from students, the visual representation utilized during teaching including the adoption of diagrams, learning aids, boards, and experiments to improve the understanding of learners; actively engaging learners, so they can develop skills; encouraging social interactions by introducing team tasks; and monitoring students by making use of feedback and assessment mechanisms to track their progress [6].

2.3 Reviewing Pedagogical Approaches

Globally, the quest to develop the employability of built-environment students is dependent on the quality of teaching practices and pedagogical approaches employed by institutions of higher learning. These approaches have been discussed extensively across existing literature, and in recent times, they have become increasingly necessary due to the 'new normal'. Several researchers have discussed the various benefits of final-year research or semester projects and its contribution to graduate employability. These research projects provide an opportunity to test the individual's learning integrity and experience via an exploration of facts that culminates the knowledge gathered through various academic levels. Some of these research projects assist students in establishing connections between their chosen careers and the world of work. These research activities also promote holistic thinking among students, increase their self-confidence and motivation, enrich their academic understanding of their chosen discipline and development of key skills (problem-solving, critical thinking, organizational and interpersonal) [35]. In improving the employability of learners and their work profile, the role of career management and development cannot be over-emphasized. According to Kuijpers and Scheerens [36] and Aliu et al. [8], career advice and development help to prepare learners for the industry by developing their job-searching skills such as interview preparation, curriculum vitae (CV) design, self-reflection and self-assessment abilities, and networking competencies. Doyle [26] suggests that career development involves several activities that cater to the career needs of learners such as professional workshops and seminars. In improving the employability of learners, another key strategy is the encouragement of mentoring among students. Mentoring is a social learning and interactive opportunity that improves learners' transition from lecture-room setting to work setting via industry involvement. According to Aliu et al. [9], industry mentors provide students with the knowledge required to thrive in their chosen careers to succeed in the world of work. More so, the presence of industry mentorship encourages career development and outcomes among students; hence, employability improvement is guaranteed. Levesque et al. [40] also suggest that industry mentoring provides students with career information, increased commitment, political and material support, on-the-job training, motivation, workplace understanding and realities, facilitation of connections for students, and role modeling. It is based on this wealth of knowledge that various pedagogical approaches in developing employability skills as seen in Table 1 were assessed in this study.

Table 1 Review of pedagogical approaches

Pedagogical approaches	Literature sources
Final-year research projects	Ryder [50]; Shaw et al. [51]; Parker [45]
Multidisciplinary teaching approaches	Al Hassan [5]
Work-integrated learning and placement opportunities	Kinash et al. [34]
Part-time employment for students	Dustmann and Van Soest [27]; Creed et al. [24]
Mentoring	McIntyre and Hagger [42]
Career pathing of students	Cao and Thomas [22]; Landrum [37]
Project-based learning (PBL)	Bell [19]
Simulation and role-play in classroom	Qing [47]; Bhattacharjee and Ghosh [21]
Visits to industry events	Aliu et al. [9]
Field trips to construction sites	Aliu et al. [9]
Integration of technical competitions	Ahlgren and Verner [2]
Volunteering and community engagement	Hall et al. [29]; Parker et al. [46]
Extra-curricular activities	Bartkus et al. [18]
International exchange programs	Kinash et al. [34]
Student government participation	Alviento [13]
Engagement in sports activities	Telford et al. [53]; Bailey et al. [17]

Source Author's compilation

3 Research Methodology

3.1 The Delphi Process

To validate these pedagogical approaches that can be employed by institutions of higher learning to develop employability skills among built-environment students, this study adopted a qualitative Delphi approach. According to Green [28], one of the major strengths of the Delphi technique is that it cuts across both the quantitative and qualitative methods of data collection and analysis. Consequently, this allows the research results and conclusions to be generally represented to the wider population.