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# **Digital Transformation in Engineering Management**

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# **Digital Transformation in Engineering Management**

## **Case studies of digital transformation in Africa**

Edited by  
**Arnesh Telukdarie**

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## **Praise for *Digital Transformation in Engineering Management***

*Digital Transformation in Engineering Management* is an exceptional work that delves deep into the fascinating world of digitalisation across various industries. The book covers a wide range of industries, including the health care sector, steel, small and medium enterprises (SMEs), mining, data collection, water architecture, and cyber-physical system (CPS). It provides an insightful analysis of each industry's unique characteristics and discusses the complexities of digital transformation at length, offering practical insights into how to navigate the constantly evolving landscape. This book is a must-read for practitioners and researchers who seek to understand the transformative potential of digitalisation. It examines real-world cases that provide valuable insights into the impact of digital innovation. Overall, *Digital Transformation in Engineering Management* is an exceptional contribution to the field of digital transformation in the twenty-first century.

**Hlobisile Mahure**, software developer and researcher at the University of Johannesburg, South Africa.

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# Dedication

This book is a tribute to the outstanding individuals who are at the forefront of driving change through innovation and to the professionals who are tirelessly working towards harnessing the immense power of digitalisation. Their hard work and dedication are instrumental in shaping a future where technology plays a pivotal role in enhancing our lives in ways we have yet to imagine. We are immensely grateful to these exceptional individuals for their relentless efforts to push the boundaries of what's possible and for their unwavering commitment to creating a better, more advanced future. We hope that their work will continue to inspire and contribute to the advancement of technology in the years to come.

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## Acknowledgments

We extend our heartfelt appreciation to the University of Johannesburg's Process, Energy, and Environmental Technology Station (UJ PEETS) for their valuable contributions to this book. UJ PEETS has played a pivotal role in enhancing the content and insights, bringing specialised knowledge and expertise to enrich the discourse on our subject matter. We are grateful for their unwavering support in our endeavour.

We also wish to express our sincere gratitude to the Manufacturing, Engineering, and Related Services Sector Education and Training Authority (merSETA) for their significant contribution to this book. merSETA's expertise and support have greatly enriched the content and understanding of the subject matter. We acknowledge and appreciate their valuable partnership in bringing this project to fruition.

**Chapter 1:** The authors extend their heartfelt thanks to the team at CHIETA for their valuable cooperation and insights that helped explore the implementation of business intelligence in the chemical and manufacturing industries.

**Chapter 2:** The authors express their sincere appreciation to Lubuto Hospital and the dedicated health care professionals in Gauteng for generously sharing with the study their experiences of the digital transformation of health care maintenance management.

**Chapter 3:** BBT Steel Manufacturers are acknowledged for their valuable input and contributions to the analysis of digital transformation in the steel industry.

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**Chapter 5:** The authors would like to express their sincere gratitude to the organisation that participated in gathering childhood development data. These organisations provided valuable insights into the role of digitalisation in this crucial domain. The authors would also like to extend their thanks to

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Mr. Regionald Mongwe, the sole developer of the CWTT application.

**Chapter 7:** The experts in water architecture are acknowledged for their valuable insights that enrich the understanding of the digital transformation in water-related industries.

**Chapter 8:** The authors extend their special thanks to the multinational corporations that participated in the discussions around reproducible and sustainable cyber-physical system implementation. Their contributions were critical to the deeper exploration of this topic.

**Chapter 9:** Finally, the FoodBev architecture experts in South Africa are acknowledged for their insights into digital systems analysis that enhanced the understanding of digital transformation in this sector.

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# Preface

*Digital Transformation in Engineering Management* is an informative and thought-provoking book that takes readers on a fascinating journey through various industries. The book covers a wide range of industries, including manufacturing, health care, steel, food and beverage, childhood development, water architecture and multinational corporations. In each chapter, the authors delve deep into the heart of these industries, offering unique insights into the innovative ways in which digitalisation is transforming companies, enhancing their efficiency, and sustainability. The book is a testament to the collaborative efforts of many organisations and individuals who generously shared their knowledge and experiences.

As we read through the narratives woven within these pages, we are inspired to embrace the future that technology beckons. The exploration of these industries showcases the immense benefits of technology in enhancing their operations and ensuring that they remain competitive in an ever-evolving world. *Digital Transformation in Engineering Management* is a must-read for practitioners, researchers, and anyone with a curious mind. It highlights the importance of embracing digitalisation and the benefits it can bring to businesses, individuals and society. Overall, this book will leave readers with a deeper understanding of the impact of technology on various industries and inspire them to recognise the transformative potential of digitalisation.

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## About the editor

Professor Arnesh Telukdarie is a well-known expert in digital businesses and a Professor at the Johannesburg Business School, University of Johannesburg. He is an Adjunct Professor at Johns Hopkins University and a Visiting Scholar at London South Bank University. Professor Telukdarie is also the research chairperson at the Johannesburg Business School, where he focuses on Industry 4.0, Society 5.0, sustainable development, business optimisation and manufacturing systems. He has provided consultation services to Transnet, Johannesburg Water, and the Council for Scientific and Industrial Research (CSIR), among others.

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## About the contributors

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**Logistic Makoni** is a skilled and dedicated individual who currently serves as a temporary Tourism Lecturer at the School of Tourism and Hospitality (STH), University of Johannesburg. In addition, he is a temporary Research Coordinator at the Johannesburg Business School. As a young

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and enthusiastic researcher and academic, Logistic is deeply committed to addressing developmental challenges in Africa, especially in the areas of planning and policy-related issues. Logistic is in the final year of his Ph.D. program at the University of Johannesburg, and his strong motivation drives him to make a positive impact in his field of expertise.

**Kedibone Moroane** holds a master's degree in business administration from the renowned Witwatersrand University in South Africa. Her skills range from policy analysis, human resource management, research, and planning. She contributed as a policy analyst at the Chamber of Mines of South Africa and thereafter held the position of Research and Skills Planning Manager at the Chemical Industries Education and Training Authority (CHIETA). Currently, she holds the position of Executive Manager in the field of research and planning at CHIETA.

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**Hlobisile Mahure** is a Software Developer and Researcher at the University of Johannesburg, South Africa. Her core areas of expertise include software development, human-computer interaction, web programming, machine learning, and research methods.

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## Chapter 1

# An introduction to digitalisation in the field of engineering management

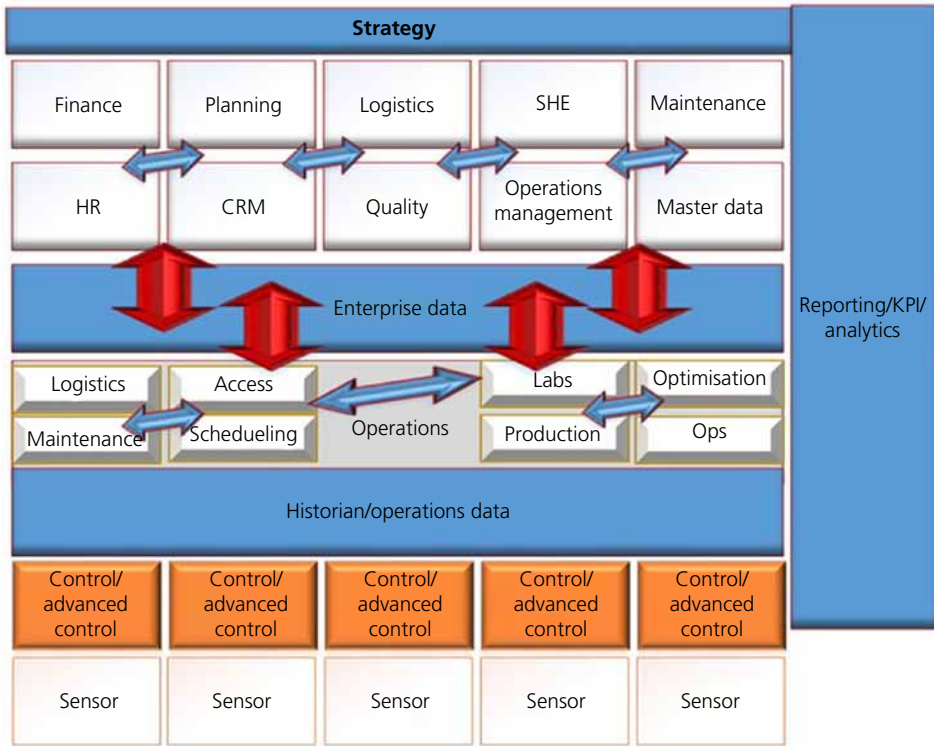
A Telukdarie and H Mahure

### Introduction

The field of engineering management, coupled with digital transformation, is an intriguing yet complex paradigm. It encompasses a range of disciplines, including project management, process optimisation, innovation management and systems engineering. These areas work together to improve organisational performance and competitiveness in this increasingly digital age. From implementing cutting-edge technologies to creating innovative business models, engineering management and digital transformation require a deep understanding of both the technical and managerial aspects of modern organisations. However, achieving an integrated, digitally engineered business is challenging. The transition to digital solutions requires practical guidance for young professionals to build confidence as they embark on their digital journey. To bridge this gap, this book offers diverse and detailed perspectives through real-world case studies, documenting the journey of industry professionals in their digital transformation journey. The case studies detail the path of effective digital transformation, showcasing the challenges and successful strategies employed. The book aims to share practical experiences and learnings from these case studies to assist in future digital implementations. It offers readers a unique opportunity to learn from the real-world experiences of industry professionals, providing them with the insights required to make informed decisions and drive successful digital transformation in their organisations.

Digital transformation is a process that involves the transformation of business operations and activities using integrated digital technologies. The process is carried out by taking a systems-based approach that can address complex challenges by incorporating multiple dimensions. Engineering management plays a crucial role in digital transformation by providing a framework for managing the design, development and implementation of integrated digital solutions. Through engineering management, businesses can effectively integrate digital technologies into their operations, optimise their processes and achieve their goals more efficiently. The goal of digital transformation is to create a more agile, efficient and innovative organisation that can stay ahead of the competition in an increasingly digital world. The architecture of such a system involves various functions that are integrated into a cohesive whole, as illustrated in [Figure 1.1](#).

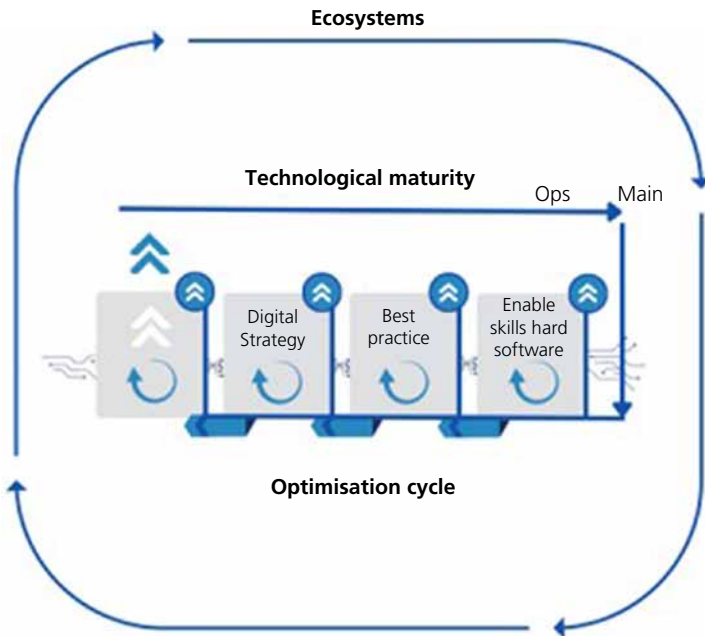
Figure 1.1 Systems-based approach: engineering management (author's own)



The advancement of the fourth industrial revolution (4IR) relies on several fundamental aspects, including horizontal, vertical and total business integration (Serumaga-Zake *et al.*, 2021; Peerally *et al.*, 2022). The collection of case studies herein illustrates these core principles in action. In addition, it is essential to integrate all business functions, such as operations, maintenance, planning, finance, human resources, quality, safety and research, into a cohesive and synergistic system to achieve optimum business optimisation. The case studies cover various aspects of the business world, including social system development, business intelligence and specialist toolset development, in both the public and private sectors. This book focuses on system thinking and consulting, as illustrated in Figure 1.2. It aims to develop system models that break down barriers to individualistic modelling and optimisation, advancing multisystem integration and optimisation.

In the age of 4IR, system thinking can deliver significant value to a single business, a value chain or an integrated system. The objective of this collection of case studies is to lead the readers towards a system paradigm, grounded in digital technology to advance future-fit thought processes. This book includes chapters that cover an extensive range of topics, including manufacturing, health care, steel, food and beverage, childhood development, water

Figure 1.2 System approach (author's own)



architecture and multinational corporations. Each chapter is dedicated to exploring the integration of digitalisation in different industries, providing unique insights into the innovative ways in which digitalisation can transform businesses, and enhance efficiency and sustainability. Each chapter further details how digitalisation is leveraged to solve industry challenges such as operational inefficiencies. The book provides an in-depth understanding of how leveraging digitalisation and innovation can improve efficiency and yield results throughout. The following is a breakdown of each chapter's uniqueness as well as the structure of the book.

The book comprises nine chapters. The first chapter provides a detailed discussion of the implementation of a business intelligence (BI) system at the Chemical Industries Education and Training Authority (CHIETA) in South Africa. The chapter offers a comprehensive overview of the role of BI in enhancing skills in forecasting, data analytics and decision-making processes. It also highlights the significance of data-driven strategies for aligning training programs with labour market requirements and achieving long-term success in skills development initiatives.

Moving forward, Chapter 2 of the book delves into the topic of digital transformation in the health care sector. The chapter presents a case study of Lubuto Hospital and how it dealt with the challenges that arose during the COVID-19 pandemic. The chapter elaborates on how integrated digital innovation is able to achieve cost-effective optimisation, outlining the steps taken to develop the digital solution. It further demonstrates how innovative methods and

digital tools can be used to solve pressing business challenges systematically. This case study aims to help readers in the industry develop their problem-solving skills and gain insights into the importance of digital transformation in the health care sector.

In the third chapter of the book, the focus is on Steel Manufacturers, and the challenges faced in forecasting due to a gap between their manufacturing and business systems. The chapter highlights how integrated digitisation played a crucial role in bridging this gap by utilising existing investments to create smart enterprises capable of efficiently managing current and future steel. The study adopts Industry 4.0 integrated technologies and proposes a framework that can be implemented in the steel sector to achieve these objectives.

Chapter 4 sheds light on the challenges and possibilities faced by small and medium-sized enterprises (SMEs) in South Africa's food and beverage manufacturing industry during their shift towards digitalisation. The chapter emphasises how SMEs in this industry face various challenges, including competition with larger businesses, financial limitations, limited access to technology, credit difficulties, skill shortages, policy restrictions and infrastructure inadequacies. However, the 4IR offers a solution for improved manufacturing, financial management and environmental sustainability through digitalisation. The chapter highlights the importance of digital transformation for SMEs to ensure their sustainability and competitiveness in South Africa's ever-changing food and beverage sector.

Chapter 5 of the book delves into the subject of digitalisation and its role in gathering data in the context of childhood development in Africa. The chapter provides an insightful account of the journey from the traditional paper-based data collection system to the development of a sophisticated digital tool for data collection and analysis. The case study highlights the challenges and opportunities involved in the transition to a digital system, including the advantages of greater efficiency, accuracy and speed of data processing.

In Chapter 6, the book examines the challenges faced by Company X in the process of digital transformation, emphasising the importance of a well-planned and integrated digital strategy. The chapter describes the various limitations of standalone digital solutions and the importance of alignment with business objectives. The study documents the development of a comprehensive digital business strategy aimed at achieving total business visibility, automation of non-value-adding activities and digitalisation of various aspects. The case emphasises the importance of effective change management for successful digital transformation, including the need for clear communication, strong leadership and employee engagement. This study provides valuable insights into the potential benefits of digitalisation and highlights the need for an integrated approach to digital transformation.

Chapter 7 of the book delves into the topic of digitalisation in water architecture and explores how advanced 4IR technologies are utilised to address the pressing issues of water scarcity and distribution in the city of Johannesburg. The case study provides a detailed account of the challenges faced by the city's water management authorities and how they leveraged digital solutions to overcome these hurdles.

Moving on to Chapter 8, the book delves into the implementation of a cyber-physical system (CPS) in a multinational enterprise (MNE) energy company. The chapter provides an in-depth analysis of the challenges faced by the company in the implementation of the CPS and how they are overcome using a range of advanced technologies.

Chapter 9 of the FoodBev architecture analysis in South Africa explores the use of 4IR technologies to enhance the efficiency, effectiveness, and impact of the FoodBev SETA. The case study highlights the development of integrated system analysis to streamline processes and elevate overall performance, as FoodBev SETA aims to remain competitive and relevant in a rapidly evolving technological landscape.

Overall, this book is an excellent resource for anyone interested in learning about the practical implementation of an integrated digital business in various industries. It offers valuable insights into how digitalisation can enhance business efficiency and sustainability. The book provides a diverse and in-depth perspective on digital transformation through real-world case studies of industry professionals who navigate the complexities of digitalisation. These case studies give valuable insights into the effective path of integrated digital transformation, highlighting the challenges, pitfalls and successes of real industry professionals. The book aims to assist future generations of professionals in their digitalisation journey by sharing the lessons learned from practical experience.

Essentially, the book provides a roadmap for effectively implementing digital transformation in the engineering sector, with diverse examples by way of case studies. It showcases real-world examples and practical guidance, making it a valuable resource for professionals seeking to navigate the complexities of digital integration with greater confidence and success. Readers will benefit from understanding the different strategies required to successfully implement business systems, and engineers will gain insights into the design process specific to each area of interest. The book also contributes to building Africa's business environment and development through practical examples of local solutions to a range of business challenges. Exploring Digitalisation in Engineering Management is an essential guide for both practitioners and researchers who want to understand the transformative potential of digitalisation.

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## Chapter 2

# Business intelligence implementation at CHIETA: addressing skills demands in the chemical and manufacturing industries

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### Introduction

Lizzy Tefo is a highly motivated and passionate individual who has dedicated her career to the field of skills development and training. As the Director of Skills Planning and Development at the Chemical Industries Education and Training Authority (CHIETA), Lizzy plays a crucial role in shaping the future of the chemical and manufacturing industries in South Africa. With a deep understanding of the challenges faced by the sector, Lizzy is committed to facilitating skills development and addressing the skills needs within the industry. She recognises that the success of CHIETA's initiatives depends on their ability to accurately identify and respond to the evolving skills landscape.

Lizzy is the driving force behind CHIETA's strategic planning efforts, with a particular focus on the Sector Skills Plan (SSP). She understands the significance of the SSP as a roadmap for guiding CHIETA's skills development interventions. To ensure the SSP's effectiveness, Lizzy leads the annual analysis of Workplace Skills Plans (WSPs) and Annual Training Reports (ATRs), meticulously examining the data and insights they provide. Through her dedication and expertise, Lizzy leverages the findings from the WSPs and ATRs to gain a comprehensive understanding of the sector's current and future learning and qualification needs. She recognises that the infrequent assessment of skills within the sector poses a significant challenge, given the rapidly changing demands of the labour market. Lizzy is determined to overcome this challenge and make the SSP a more dynamic and proactive tool for skills forecasting.

Lizzy actively collaborates with industry stakeholders (University of Johannesburg Business School), conducts research, and explores innovative approaches to enhance CHIETA's skill forecasting capabilities. She understands the importance of leveraging data analytics and industry insights to predict future skills needs accurately. By doing so, Lizzy aims to ensure that CHIETA and the entire SETA network can adapt their skills training programmes to meet the evolving demands of the labour market effectively. Lizzy's passion, expertise, and strategic thinking will be instrumental in navigating the challenges faced by CHIETA.

Her role as the Director of Skills Planning and Development empowers her to drive change, shape industry collaborations, and influence the allocation of funds towards priority skills development initiatives. Lizzy's journey will showcase the critical role of proactive skills planning in equipping the chemical and manufacturing industries with the necessary competencies for sustainable growth and competitiveness.

## **The Chemical Industries Education and Training Authority (CHIETA)**

The Chemical Industries Education and Training Authority (CHIETA), established by the Skills Development Act in 1998, plays a vital role in facilitating skills development and addressing the skills needs within the chemical and manufacturing industries in South Africa. As one of the 21 Sector Education and Training Authorities (SETAs) in the country, CHIETA is responsible for implementing various learning programmes, including learnerships, skills programmes, internships and other strategic initiatives to enhance the skills of the workforce.

To support the development of skills in the sector, CHIETA allocates a significant portion of the Skills Development Levies (SDL) obtained from the chemical industry. Approximately 70% of the SDL is distributed back to member companies through mandatory and discretionary grants. Mandatory grants are provided to companies that fulfil the requirements, ensuring that they receive the essential support for skills development. These grants serve as a critical source of funding for companies to enhance the skills of their employees and meet industry standards. In addition to the mandatory grants, CHIETA also offers discretionary grants. These grants are awarded at the discretion of CHIETA for skills development projects linked to scarce and critical skills. By providing discretionary grants, CHIETA supports initiatives that address the specific skills needs of the sector, fostering the growth and competitiveness of the chemical and manufacturing industries.

This flexible funding mechanism allows CHIETA to adapt to the evolving skills landscape and prioritise investments in areas that have the greatest impact on the industry. As a trusted partner in skills development and training for the chemical sector, CHIETA funds various occupational programmes as well as certain Technical and Vocational Education and Training (TVET) sector and higher education programmes. The allocation of funds is guided by CHIETA's well-researched SSP, which documents the hard-to-fill skills and hard-to-fill positions within the sector. The SSP provides a roadmap for CHIETA's skills development interventions, ensuring that resources are directed towards areas of critical need.

However, the infrequent assessment of the SSP within the sector poses a significant challenge for CHIETA. The labour market is constantly evolving, driven by technological advancements, industry shifts and changing economic conditions. Without regular evaluations, there is a risk of the skills gaps widening and the workforce being ill-prepared to meet industry demands. To overcome this challenge, CHIETA recognises the importance of adopting a proactive approach to predicting future skills needs. By leveraging data analytics, conducting comprehensive research and engaging with industry stakeholders, CHIETA aims to enhance its skills forecasting capabilities to stay ahead of emerging skills requirements.