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Wilson R. Nyemba • Charles Mbohwa
Keith F. Carter

Bridging the Academia Industry Divide

Innovation and Industrialisation Perspective using Systems Thinking Research in Sub-Saharan Africa

Springer

EAI
RESEARCH MEETS INNOVATION

Wilson R. Nyemba
Quality Assurance and Operations Management
University of Johannesburg
Johannesburg, South Africa

Charles Mbohwa
Pro-Vice Chancellor responsible for Strategic Partnerships and Industrialisation
University of Zimbabwe
Harare, Zimbabwe

Keith F. Carter
School of Engineering
University of Leicester
Leicester, UK

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We sincerely dedicate this book to our families and colleagues who made it possible!

To all the engineers and system thinkers who have helped and continue to engineer a better world in a creative and innovative manner, disruptive as it may be, but necessary!

"You cannot carry out fundamental change without a certain amount of madness. In this case, it comes from non-conformity, the courage to turn your back on the old formulas, the courage to invent the future. It took the madmen of yesterday for us to be able to act with extreme clarity today. I want to be one of those madmen. We must dare to invent the future".

–Thomas Sankara (1985):
President of Burkina Faso

"Are engineers better at business than business people? It's debatable. Business people certainly seem to have bigger houses, drive fancier cars, wear nicer clothes and have better looking mates. Engineers lack the time and management skills to spend that kind of money. They waste all their time inventing ways to make the most money in the quickest, most efficient way possible. And then when they figure it out, they optimise the process".

–Raul Perez

Preface

Bridging the Academia Industry Divide: Innovation and Industrialisation Perspective Using Systems Thinking Research in Sub-Saharan Africa is a book that culminated from years of research following a realisation of the gap and mismatch of engineering skills produced by universities and those that industry required. Based on case studies in Sub-Saharan Africa, the initiatives included collaborations and secondments with the aim of bridging the gap between academia and industry through systems thinking research, aided initially by the Swedish International Development Cooperation Agency (Sida) through the Network of Users of Scientific Equipment in Eastern and Southern Africa (NUSESA) (1989–2005). The initiatives were later revamped and supported by the Royal Academy of Engineering through the Enriching Engineering Education Program (EEEP) (2013–2015) and the Higher Education Partnerships for Sub-Saharan Africa (HEP SSA) (2019–2021) in partnership with tertiary institutions in Southern Africa and the University of Leicester in the UK, anchored by SADC governments, regional industry, research institutions, professional engineering and regulatory bodies, out of which the Southern Africa Engineering Education Network (SAE^2Net) was established.

The book provides information on how to model, simulate, adjust and implement integrated systems thinking frameworks to improve the quality of engineering education and training for capacity building and sustainability. The book also covers approaches to address research gaps and mismatch of skills while capitalising on the successes of the NUSESA, EEEP and HEP SSA initiatives. The book primarily consists of the novel research and innovation approach of modelling and building systems thinking sub-models which were eventually integrated into the Universal Systems Thinking (UST) model ("bridge") to assist engineering academics and engineers in industry to build capacity and cope with the rapid and dynamic trends in technology in view of the widespread implementation and impact of the 4th Industrial Revolution and in preparation for the Digital Ecosystem, an era predicted to be dominated by critical and system thinkers equipped with creative and innovative skills. The book is also useful for policy-making researchers in academia, industrial and public sector researchers, and implementers in governments that

provide required funding for the development of human resources and engineering skills to drive industry. Not only is the book a reference guide for engineering practitioners but is also a cocktail of experiences benchmarked on industrialised and semi-industrialised economies to create a blend and best practices for bridging the gap between academia and industry in industrialising economies.

Johannesburg, South Africa — Wilson R. Nyemba
Harare, Zimbabwe — Charles Mbohwa
Leicester, UK — Keith F. Carter

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We wish to thank the Swedish International Development Cooperation Agency (Sida) who opened the doors to pursue this research through the Network of Users of Scientific Equipment in Eastern and Southern Africa (NUSESA) which formed a firm foundation for the collaborations in engineering education in Sub-Saharan Africa.

Our sincere gratitude and appreciation to the Royal Academy of Engineering who revamped the Sida support and expanded it to include the vital missing link of industry players through the Enriching Engineering Education Program (EEEP) and the scaled up Higher Education Partnerships for Sub-Saharan Africa (HEP SSA). Their decade-long support helped to strengthen the ties between academia and industry in Southern Africa, apart from other support initiatives such as the Industry Academia Partnership Program, Africa Catalyst and the Africa Prize for Engineering Innovation.

We are also grateful for the different contributions made by several industry partners, government ministries, professional engineering and regulatory bodies as well as research institutes in Southern Africa, inclusive of technology transfer, equipment and the UZ-Zimplats Professorial Chair in Mining Engineering. We are equally indebted to the assistance and work carried out by students and engineering academics who were attached or seconded to the different sectors of industry and for the valuable work carried out and information gathered, culminating in several scholarly publications.

Our colleagues from the University of Zimbabwe HEP SSA Implementation Committee (Management) and the regional HEP SSA Steering Committee (Board) contributed immensely in shaping the direction and eventual compilation of this book and the establishment of the Southern Africa Engineering Education Network (SAE^{2}Net).

We are all indebted to our families for the sacrifice and time spent away from them to ensure that this work was completed and above all the Almighty for giving us the strength and wisdom to continue.

"*It always seems impossible until it's done*". – Nelson Mandela.

Wilson R. Nyemba
Charles Mbohwa
Keith F. Carter

Abbreviations

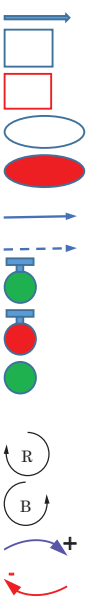
BMR	Base Metal Refinery
BOT	Build-Operate-Transfer
BUSH	Biomass Utilisation by Sustainable Harvest
CNC	Computer Numerical Control
CREEE	Centre for Renewable Energy and Energy Efficiency
CUT	Chinhoyi University of Technology
DAM	Day Ahead Marketing
EDF	European Development Fund
EEEP	Enriching Engineering Education Program
FAO	Food and Agricultural Organisation
GCRF	Global Challenges Research Fund
GSM	Global System for Mobile Communications
GTZ	German Technical Cooperation Agency (GIZ)
HEP SSA	Higher Education Partnerships for Sub-Saharan Africa
HIT	Harare Institute of Technology
HPGR	High Pressure Grinding Rolls
IBL	Industry Based Learning
IDT	Industrial Design Thinking
JICA	Japan International Cooperation Agency
MU	Makerere University
NEED	Network of Energy Excellence for Development
NEPAD	New Partnerships for Africa's Development
NUSESA	Network of Users of Scientific Equipment in Eastern and Southern Africa
NUST	Namibia University of Science and Technology
NUST Z	National University of Science and Technology, Zimbabwe
ODA	Overseas Development Authority
OECD	Organisation for Economic Cooperation and Development
OEM	Original Equipment Manufacturers
PARTICIPA	Participatory Integrated Assessment of Energy Systems to Promote Energy Access and Efficiency

PBL	Problem Based Learning
PhD	Doctor of Philosophy
PMR	Precious Metal Refinery
PPP	Public Private Partnerships
R&D	Research and Development
RAEng	Royal Academy of Engineering
SADC	Southern Africa Development Community
SAE^{2}Net	Southern Africa Engineering Education Network
Sida	Swedish International Development Co-operation Agency
SPP	Smart Procurement Partnerships
UDSM	University of Dar es Salaam
UEM	Universidade Eduardo Mondlane
UN	United Nations
UNESCO-IHE	United Nations Education, Scientific and Cultural Organisation – Institute for Water Education
USAID	United States Agency for International Development
UJ	University of Johannesburg
UZ	University of Zimbabwe
ZIMDEF	Zimbabwe Manpower Development Fund
ZNDU	Zimbabwe National Defence University

Nomenclature

Au	Gold
c	Concentrate
f	Feedrate
$E(t)$	Residence time distribution for continuous flotation
$F(k)$	Distribution function for mineral types with different flotation rates
H	Half-width
k	Kinetic rate constant for sub-processes
n	Number of replications
N	Number of parts
Pd	Palladium
Pt	Platinum
R	Recovery of minerals at time t
R_∞	Maximum recovery at infinite time
Rh	Rhodium
s	Sample standard deviation
S	Number of stages in a process
t	Time in minutes
ta	Tailings
T_s	Total time in system
T_q	Total queueing time
T_w	Time spent by N parts through W workstations
W	Number of workstations

Symbols



Systems Thinking Process Flow

Systems Thinking Elements

Constraints/Challenges

Process Flow Outputs/Decisions/Functions

Feedback Process for Improvement

Compulsory Link/Interconnection and Direction

Flexible or Optional Link/Interconnection and Direction

Processing: Simulating/Controlling/Optimising

Adjustments

Acceptable Outcome for Decision Making, Conclusions or Recommendations

Positive Reinforcing Feedback Loop

Negative Balancing Feedback Loop

Positive Link/Feedback

Negative Link/Feedback

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About the Authors

Wilson R. Nyemba is a senior lecturer in mechanical engineering at the University of Zimbabwe with over 30 years of experience both in industry and academia. He designed and developed a wide range of engineering products in different capacities in industry from product development to engineering management. He also formulated and led a number of successful ventures at the University of Zimbabwe where he served as Dean of the Faculty of Engineering. He also served as Chairman of WaterNet and project manager for the Royal Academy of Engineering projects for enhancing the quality of engineering education in Southern Africa. He is an accomplished consultant and researcher with interests in engineering education, capacity building and sustainability, systems thinking and modelling. He holds a BSc honours degree in mechanical engineering from the University of Zimbabwe, an MSc degree in advanced mechanical engineering from the University of Warwick in England and a Doctor of Engineering degree in mechanical engineering from the University of Johannesburg in South Africa. He is also currently co-appointed as a senior research associate in the Department of Quality Assurance and Operations Management at the University of Johannesburg. He has authored and published 55 peer-reviewed papers in journals and conference proceedings as well as several consultancy reports. He has received several awards and recognition for outstanding research.

Charles Mbohwa is the University of Zimbabwe provice chancellor responsible for strategic partnerships and industrialisation as well as a visiting professor at the University of Johannesburg. He previously worked for the National Railways of Zimbabwe and the University of Zimbabwe as a senior lecturer and head of Department of Mechanical Engineering. He has extensively published papers in peer-reviewed journals and conferences as well as book chapters and 5 books. He holds a BSc honours degree in mechanical engineering from the University of Zimbabwe, a Master of Science in operations management and manufacturing systems from the University of Nottingham and a Doctor of Engineering from the Tokyo Metropolitan Institute of Technology in Japan. He was a Fulbright scholar in 2006–2007 at the Supply Chain and Logistics Institute, School of Industrial and Systems Engineering, Georgia Institute of Technology, as well as a Japan Foundation fellow. He is also a reviewer for more than 20 international journals and is a member of the editorial boards/committees of 5 journals.

Keith F. Carter is a chartered mechanical and nuclear consultant engineer who has also trained as a naval architect. He is a director and principal consultant for Keimar Consultancy in Leicester, England. Over the last 15 years, Keith has been associated with a wide variety of engineering projects for Rolls-Royce at Derby, England, in both the nuclear marine and aerospace divisions principally specialising in structural integrity issues. He has also carried out other significant projects in a variety of fields, including the analysis of AGR graphite cores for British Energy (EDF). Dr. Carter also holds the post of visiting design professor within the School of Engineering at the University of Leicester in England, bringing in considerable engineering and industrial experience to the teaching of students and to various research projects. He holds a Bachelor of Science degree in chemistry and a PhD in statistical mechanics using computer simulation, both from the Royal Holloway College at the University of London and has authored over 30 academic papers as well as numerous reports for client companies.