The MASK Methodology and Knowledge Books

WORKING METHODS FOR KNOWLEDGE MANAGEMENT

Knowledge Economies and Knowledge Work
Bill Lafayette, Wayne Curtis, Denise Bedford, and Seema Iyer

Knowledge Assets and Knowledge Audits
Pawan Handa, Jean Pagani, and Denise Bedford

Critical Capabilities and Competencies for Knowledge Organizations
Juan Cegarra-Navarro, Alexeis Garcia-Perez, Susan Wakabayashi, Denise Bedford, and Margo Thomas

Designing and Tracking Knowledge Management Metrics
Alexeis Garcia-Perez, Farah Gheriss and Denise Bedford

Translating Knowledge Management Visions into Strategies
Monique Ceruti, Angel Williams and Denise Bedford

Assessment Strategies for Knowledge Organizations
Dean Testa, Johel Brown-Grant, and Denise Bedford

Learning Organizations
Malva Daniel Reid, Jyldyz Bekbalaeva, Denise Bedford, Alexeis Garcia-Perez, and Dwane Jones

Knowledge Networks
Denise Bedford and Thomas W. Sanchez

Organizational Intelligence and Knowledge Analytics
Brian McBreen, John Silson, and Denise Bedford

Communicating Knowledge
Denise Bedford, Ira Chalphin, Karen Dietz, and Karla Phlypo

The Cultures of Knowledge Organizations: Knowledge, Learning, Collaboration (KLC)
Wioleta Kucharska and Denise Bedford

Knowledge Preservation and Curation
Margie Foster, Hossein Arvand, Hugh Graham, and Denise Bedford

Knowledge Translation
Constantin Bratianu, Alexeis Garcia-Perez, Francesca Dal Mas, and Denise Bedford

Forthcoming
Knowledge Ethics for the Knowledge Economy
Benjamin Anyacho, Cynthia Hilsinger, Norman Mooradian, Jelina Haines, MalgorzataZieba, and Denise Bedford

Strategic Intelligence for a Knowledge Economy
Brian McBreen, Pawan Handa, Cory Cannon, Liz Herman, Michael Molina, Alexeis Garcia-Perez, and Denise Bedford

The Knowledge of Communities
John Edwards, Nancy J. Meyer, Ellen M. Oman, Denise Bedford, Pat Kerrigan and Alexeis Garcia-Perez

Knowledge Flows in Places and Spaces
Jayne Sappington, Alexeis Garcia-Perez and Denise Bedford

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Contents

Section 3: Design and Development of a Knowledge Book

Appendices

Introduction to the Series

Knowledge sciences as a discipline has a rich and diverse history dating back to the 1950s. In the past 70 years, the discipline has drawn theory and practice from economics, engineering, communications, learning sciences, technology, information sciences, psychology, social sciences, and business and organization management. To craft this discipline, we have developed our own language and terminologies, established our own peer-reviewed journals and built a rich research foundation, created a gray literature, and established a series of networks and conferences. Over the decades, there have been many knowledge management education programs, but there is no consistent curriculum and few have been sustained. It has been challenging for new practitioners to gain an understanding of the field. And, while the practice of knowledge management is growing around the world, it has not yet achieved the expected organizational stature. For knowledge management to rise to the stature of other business functions and operations, it must be able to speak the language of business, and align with and support the way the organization works.

This series is designed for business and knowledge management practitioners. "Working Methods for Knowledge Management" is a multi-year and multi-volume series designed to address each and all of the methods required to establish and sustain an organization-wide knowledge management function. The goal of the series is to provide a business perspective on each topic. Each book begins by grounding the method in the business context – and then translates established business models and methods to a knowledge management context. It is often the case that this translation expands and extends the business model and method.

The knowledge management literature is rich with introductory handbooks, guidebooks, cookbooks, toolkits, and practical introductions. This literature is an important starting point for anyone new to the discipline. We recommend any and all of these books as a way to build a fundamental understanding of the scope and coverage of the field. These texts will provide a good 10–20 page introduction to all of the key issues you need to be aware of as you embark on a new career in the field or have been assigned a new knowledge management role or responsibility. Once you have that grounding, though, we recommend that you look to the "Working Methods for Knowledge Management" texts as an intermediate source for understanding "What comes next? What now?"

Just as this series is not intended as a starting point for the field, neither is it an ending point. Each text is designed to support practical application and to foster a broader discussion of practice. It is through practical application and extended

discussion that we will advance theory and research. The editors anticipate that as the practice expands, there will be a need to update the texts – based on what we are learning. Furthermore, the editors hope the texts are written in a way that allows business managers to extend their work to include knowledge management functions and assets. We will learn most from expanding the discussion beyond our core community.

Joint Enterprise, Mutual Engagement, and a Shared Repertoire

From the outset, the publisher and the editors have established a new and different approach to designing and writing the books. Each text is supported by a team of authors who represent multiple and diverse views of the topic. Each team includes academics, practitioners, and thought leaders. Every author has grappled with the topic in a real-world context. Every author sees the topic differently today than they did when the project began. Over the course of several months, through weekly virtual discussions, the scope and coverage were defined. Through mutual engagement and open sharing, each team developed a joint enterprise and commitment to the topic that is enduring. Every author learned through the discussion and writing process. Each project has resulted in a new shared repertoire. We practiced knowledge management to write about knowledge management. We "ate our own dog food."

Acknowledgments of Early Support

The series is a massive effort. If there is value in the series, much of the credit must go to two individuals – Dr Elias Carayannis, George Washington University, and Dr Manlio Del Giudice, University of Rome. It was Dr Carayannis who first encouraged us to develop a proposal for Emerald Publishers. Of course, this encouragement was just the most recent form of support from Dr Carayannis. He has been a mentor and coach for close to 20 years. It was Dr Carayannis who first taught me the importance of aligning knowledge management with business administration and organizational management. Dr Del Giudice has been generous with his guidance – particularly in setting a high standard for any and all knowledge management research and practice. We are grateful to him for his careful review and critique of our initial proposal. His patience and thoughtful coaching of colleagues are rare in any field. The field will reach its full potential as long as we have teachers and editors like Dr Del Giudice.

Preface

Overview of the Subject Matter

The focus of this book is knowledge engineering, and Dr Ermine's Method for Analyzing and Structuring Knowledge (MASK) methodology and the process of building Knowledge Books. The readers might reasonably ask why we needed to write a book about a framework and methodology which are already extensively documented in the peer review literature, that is, thousands of citations, and where we can find examples of Knowledge Books constructed for numerous organizations. This is a reasonable question. Let us explain why this book is necessary and how it is different from the scholarly literature.

In the past five years, the field of knowledge management has undergone a dramatic shift. Prior to 2020, practitioners and professionals in the field spoke about the three generations of knowledge management. The three generations described how knowledge management moved from an information management focus to a technology focus, and finally to a knowledge focus. Having finally clarified the focus on knowledge, the field began to expand to include broader treatments such as knowledge economy, knowledge architecture, knowledge communication, knowledge cultures, knowledge networks, and other areas. Having clarified the focus, we began to review what we thought we knew in the earlier generations of evolution. We have revisited many of the earlier principles and perceptions and found that some need to be rethought, others that we discarded are more critical today, and some, in fact, do not fit in the field of knowledge management. In fact, the field has now been relabeled as knowledge sciences.

In 2020, the shift in the discipline was accelerated due to several causes, primarily because of the COVID-19 pandemic. The COVID-19 pandemic isolated each of us. We had to learn to do things for ourselves, to grow and use our own knowledge, and to do all this in a digital environment. It forced us into what was essentially a new world. Immediately prior to COVID-19, the widespread availability of technologies and new tools the average person could learn to use and broader access to both knowledge and information sources transformed who could engage in knowledge management, why, and where.

The first effect we observed was that knowledge management has moved beyond a single office in an organization. It is no longer limited to a designated person or team, not to a designated functional responsibility, or a capability in organizations. Within organizations, it is now the responsibility of every individual

employee to "see" leverage and grow their own knowledge capital. This effect is a sign that an emerging and immature knowledge economy is rapidly maturing.

The second major shift pertains to who does knowledge management. In earlier decades, a few highly placed individuals were responsible for knowledge management on behalf of the organization. Today every individual does knowledge management. We talk less about knowledge management in our organizations, and we do knowledge management more – every day, in every task, and in every decision. As a result, knowledge management has now moved beyond the organization into everyday life. These shifts tell us that knowledge management, and particularly the representation, preservation, curation, and active use of knowledge, is no longer limited to highly skilled and trained knowledge professionals and engineers. It is now a competency that everyone sees as important in the knowledge economy. As a result, we now realize that we need methods and practices that are understandable and accessible to everyone. We realize that we have a major challenge in making tacit knowledge available to other people. We have a knowledge foundation to draw from. However, it is only understandable to highly skilled and trained knowledge engineers, computer scientists, and systems developers.

Over the past 40 years, a new field of study and practice has developed – knowledge engineering. The challenge has been that this field has high barriers to entry, as it requires an understanding of computer science, systems design, formal representation languages, and specifications. Most knowledge scientists are challenged to understand or enter this field. A critical framework, conceptualization, and methodology grew out of this specialized field – Professor Ermine's MASK methodology and the construction of Knowledge Books. It provides a critical bridge from the formal languages and specifications of knowledge engineers designed for use by machines and knowledge systems, to a human understandable representation of knowledge. Professor Ermine's methodology translates the conceptual framework of knowledge engineering into common, everyday models that most people are familiar with and understand. The need for a popular understanding of the framework and methods is now critical.

We wrote this book to bring this important framework and methodology to business managers, to knowledge professionals and practitioners, and knowledge curators. We wrote this book to make that methodology more widely available to people who will need or want to use it. This book should be considered both a representation of the more formalized approaches and models used in knowledge engineering and a textbook for those who wish to build a Knowledge Book for their organizations. Our goal has been to not only provide a translation of the models, but also to offer the readers a step-by-step approach for designing and construction.

This book makes the case for a greater awareness of the knowledge capital of every individual. The authors highlight the importance of having more popular approaches to recognizing, growing, and valuing the knowledge assets of the public to fuel a knowledge economy. The book also makes the case for a broader and more inclusive discussion of knowledge engineering in the knowledge sciences field – going beyond the engineering, computer science, and artificial intelligence

fields. Furthermore, it argues for a broader spectrum of approaches to knowledge engineering that support both human and machine knowledge elicitation and representation. Another critical vulnerability that surfaced in writing the book is the still immature field of knowledge elicitation. The authors observed that far more attention is given to knowledge extraction – which is, in fact, information extraction than to knowledge elicitation. This has resulted in a slower than needed growth of knowledge and practice in that field. The authors speak more extensively about the challenges of knowledge elicitation and make the case for more investment in this field of study.

The primary argument, though, is for the value of and need for greater awareness of the MASK methodology. The demand for Knowledge Book construction is growing, and today there are only a handful of knowledge engineers who are experienced in the craft. There must be more who can build Knowledge Books. Additionally, each new Knowledge Book constructed generates new insights into what is possible. Expanded experience with the methodology and the practice will facilitate its use in all environments, fields, and kinds of organizations.

The authors make the case for more dialog between knowledge engineers, knowledge professionals, and knowledge practitioners. The authors also make the case for an open dialog between knowledge professionals and practitioners with the public that will lead to more thoughtful growth and use of knowledge capital.

Where the Topic Fits in the World Today

Like the other books in the series, this text draws from and integrates research and practice from several different disciplines. The primary goal of the series is to create stronger ties between the business management and knowledge management disciplines.

Maturity of the Topic

The book touches upon and draws from several topics. Some elements of the topic are mature whereas others are not. For example, the formal systems engineering field is mature. Knowledge engineering is mature in the fields of computer science and engineering. In the field of knowledge sciences, though, it is immature. Knowledge elicitation is an immature field. It had a strong beginning but has had less scholarly investment and use than knowledge extraction. Knowledge extraction has had more attention and investment because of the computational linguistics and language models of the past 20 years. Knowledge elicitation methods are maturing but are not yet sufficient. Additionally, knowledge representation methods are immature outside of explicit data and information. In contrast to these states, the MASK methodology is a mature and reliable framework and practice. It simply needs translating for everyday business managers and people. The book is a first step toward providing a textbook that may be used to introduce students in business schools and schools of information science.

Where the Book Fits in the Literature Today

This is the 14th book in the "Working Methods for Knowledge Management" series. The text aims to create a translation of a formal knowledge engineering conceptual framework, language, and practice for everyday business managers and people. It aims to fill a significant gap in the knowledge sciences literature. In fact, this book is about knowledge engineering. It speaks to the two primary components of knowledge engineering – knowledge elicitation and knowledge representation. It aims to fill a gap in the literature we know will widen and deepen in the coming years. The book aims to extend knowledge engineering to non-engineers, and to provide greater access to the theory and methodology of MASK.

The Intended Audience for the Book

The construction of Knowledge Books is not an insignificant investment of time and resources. The result is highly valuable to any organization in that it preserves business-critical knowledge in a readily available, accessible, and consumable form. Like any attempt to elicit and represent knowledge, though, it requires a commitment of experts and knowledge sources for periods of time. The construction of Knowledge Books carries opportunity costs. This text is written for organizational executives and business managers who are contemplating a Knowledge Book project. The authors hope it will assist managers in realistically assessing costs and staff investments of time and a reliable sense of the value of the product.

The book is written for knowledge management practitioners and professionals who should take an active role in the design and construction of Knowledge Books. For this audience, the book provides a textbook approach to understanding the context, the framework, and a step-by-step approach to design and construction.

The book is also written as a textbook for teaching a popular version of knowledge engineering in knowledge sciences, information sciences, and business school curricula. Finally, the book is written for everyday individuals who have an innate sense of the need for knowledge elicitation, representation, and leverage – but do not know where to begin.

Structure of the Book

The book is organized into three sections and fifteen chapters. "Engineering Critical Business Knowledge" section sets the context for the book by providing a history and overview of the field of knowledge engineering and what it means to apply engineering methods to knowledge. "The Theory of MASK and the Development of Knowledge Books" section provides an in-depth discussion of the theory of MASK and the development of Knowledge Books. "Design and Development of a Knowledge Book" section translates the theory of MASK and the six knowledge models into a language and context knowledge professionals and practitioners, business leaders, faculty, and students can understand. Finally,

Appendix 1 provides a high-level project plan that the readers can use as a template for designing their own approach. Each task and subtask in the project plan traces back to a chapter in the book.

Chapter Summaries

Each chapter follows a common framework. The authors explain why the chapter is important. Each chapter provides background information on the topic as well as references to additional resources – both theory and practice. Challenges and opportunities for new work are highlighted for each topic. The focus of each chapter is summarized below.

Chapter 1 explains how and why the knowledge economy will increase the demand for knowledge engineering. It defines and traces the evolution of knowledge engineering. It identifies the two components of knowledge engineering – elicitation and representation. The authors discuss the increased importance of tacit knowledge, specifically know-what and know-how, for organizations and companies. The increased demand for knowledge engineering calls for an increased number of knowledge engineers. Knowledge engineering will expand beyond its current homes in systems development and cognitive science. The MASK methodology is an important intermediary between formal knowledge engineering and the methods needed to develop natural language and conceptual modeling for the knowledge economy.

Chapter 2 considers the challenges of applying engineering practices to knowledge. Knowledge cannot be managed like other forms of capital because it is tacit and intangible. Research has identified economic properties and behaviors that set it apart from physical and financial capital. The authors translate the economic typology of human, structural, and relational capital to Blakely's embrained, embodied, embedded, and encultured characterizations. Knowledge elicitation techniques are discussed and aligned with Blakely's four forms.

Chapter 3 provides a deep dive into the theory, research, and models of tacit and explicit knowledge. The authors describe knowledge flows and knowledge creation in an organization. The authors introduce Polanyi's and Nonaka Takeuchi's definitions and describe Ermine's structural model of tacit and explicit institutional knowledge capital. Tacit and explicit knowledge are explained as organizational knowledge capital. The organizational knowledge model is presented. The chapter also describes tacit knowledge as organizational knowledge capital. Finally, the chapter addresses mapping the AIK system.

Chapter 4 explores the nature of knowledge codification. The chapter discusses the knowledge codification process and explains how it aligns with the broader field of knowledge engineering. The authors break the knowledge codification process into (1) knowledge modeling, (2) knowledge representation and modeling of semantic memory, and (3) knowledge representation and modeling of semiotic networks. The chapter also defines object-oriented models, the representation of tasks, and process modeling. The authors also focus on the total concept and methods of knowledge engineering that are at the origin of the MASK Knowledge Book technique.

Chapter 5 presents the principles of knowledge representation according to the MASK methodology. The authors present knowledge as a representation, and the structure of knowledge as a representation. The semiotic triangle of knowledge is discussed, as well as the systematic triangle of knowledge. The MASK approach to representing knowledge is introduced, including knowledge as representation and knowledge as meaning.

Chapter 6 discusses that knowledge in an organization is found in its information. Explicit information sources are helpful in seeing and finding the embedded tacit knowledge. Where explicit sources do not provide a full view of tacit knowledge, it must be created. In this chapter, the authors define what it means to elicit and represent tacit knowledge in its six dimensions. These dimensions are the six fundamental types of knowledge addressed in the MASK methodology, including the phenomenon model, the activity model, the history perspective, the concept perspective, and the evolution or lineage model. The authors explain how each model is both a visual and an actual language, with precise syntax and semantics. The models are illustrated through use cases.

Chapter 7 provides an in-depth explanation and description of each of the six models of the MASK framework. The authors explain how each model represents a type of knowledge that is critical to creating a holistic representation of a topic. The chapter provides an overview of the six types of knowledge represented in the models. It speaks to the challenge of recognizing and describing the underlying types of knowledge and offers use-case examples to illustrate the knowledge.

Chapter 8 presents the history of the Knowledge Book technique. This technique represents an important evolution of formal knowledge engineering methods to an easier to understand and use knowledge engineering language. In its evolution, it has also produced the idea of Knowledge Books which makes knowledge engineering theory and practice more available, accessible, and usable to non-knowledge engineers and non-systems developers. This is an important evolution for meeting the demand for knowledge representation in a maturing knowledge economy.

Chapter 9 introduces the concept of a Knowledge Book. It walks the readers through a 11-step procedure for designing and constructing a Knowledge Book. It addresses some key steps that are important to a successful Knowledge Book product, specifically addressing issues that are external to the knowledge models. It addresses project scoping, budget, and planning, designing the architecture of a Knowledge Book, identifying information sources, developing an elicitation strategy, building prototypes, testing, and assessing the product, and operationalizing a Knowledge Book. The chapter also addresses the critical step of planning for sustainability and ongoing support.

Chapter 10 focuses on designing and constructing a phenomenon model. Phenomena are like systems. Designing a phenomenon model is not dissimilar from designing and constructing a systems model. The essential elements of a systems model are presented and aligned with the MASK phenomenon model. The importance of focusing on the phenomenon model first in the chain of six models is also stressed. The authors explain what we can learn from a phenomenon

model, and the consequences of overlooking or avoiding the model are explained. A step-by-step methodology, well-suited elicitation methods, and suggestions for sourcing information are presented.

Chapter 11 describes the nature and importance of the activity model. The authors explain what we learn from this model and the shift it represents from an external and broader view of knowledge to activities related to the knowledge itself. The challenges and confusion associated with an activity model are explained. The authors suggest a clarification for understanding and designing an activity model. The similarities to business capability models are identified. A step-by-step approach to building an activity model is described, as well as its alignment with developing business capability modeling.

Chapter 12 focuses on designing and constructing a history model. The authors explain why the history perspective is important and what we learn from it. The authors explain the history model in relation to common everyday forms, including project and historical timelines, process times lines, events, and life cycle timelines. The formats of timelines are also referenced. The common reference points are useful for designing and presenting the history model to Knowledge Book users. The authors explain why it is important to develop the history model after the phenomenon model. A step-by-step methodology for constructing a history model is included.

Chapter 13 focuses on the MASK concept model as a hierarchical taxonomy and in relation to ontologies developed for knowledge-based systems. The authors differentiate concepts from terms and explain the value of a concept map. Every day examples of concept models are described. A step-by-step methodology for constructing a concept model is provided. The authors explain why concept models are developed after activity and task models.

Chapter 14 describes the task model. The authors explain the purpose of a task model and note what we can learn from it. They clarify what we mean by a task model and explain how it does and does not align with workflows, activities, and business processes. The authors describe tasks in the context of task analysis. The key elements of a MASK task model are highlighted. A step-by-step approach for constructing a task model is included. Furthermore, the challenges of designing an interface for a complex knowledge object are discussed.

Finally, in Chapter 15, the authors focus on the design and construction of the lineage model. We learn what lineage is and how it applies to knowledge. The lineage model is differentiated from a history model. The authors explain that the history model pertains to the evolution of the environment in which knowledge develops, whereas lineage pertains to the evolution of the knowledge itself. Lineage examples are found in everyday examples such as ancestries, provenance, versions, and citation networks. A step-by-step methodology for building a lineage model is described.

How the Book Impacts the Field

The primary impact intended by the field is to the field of knowledge sciences. Knowledge sciences are the true home for the theory and practice of MASK. The

conceptual framework and models are core to our understanding of knowledge. The six conceptual models fill a gap that most knowledge managers did not know existed. The MASK methodology and Knowledge Books succeed where many other forms of representation have failed over the decades. The methodology is multi-dimensional – it creates a deep and holistic view of knowledge. It is particularly relevant to the representation of structural and procedural knowledge.

The book anchors the discussion of knowledge representation in everyday language without sacrificing the critical underlying theory and abstraction required to support rapidly advancing knowledge-based systems design and development. Ideally, the book adds to knowledge professionals' and practitioners' understanding of some of the key challenges of knowledge elicitation, representation, absorption, and use. For far too many years, these have been treated at a superficial level in the field of knowledge management. The time has come to take up these critical issues.

The book makes a long overdue connection between three isolated communities – knowledge engineers, knowledge professionals and practitioners, and business managers and workers. The authors hope it will bring the methodology to the attention of a broader audience.

Notes From the Authors

Every book in the "Working Methods for Knowledge Management" series generates a similarly looking product. Every book is written in a single voice achieved through conversations, exchange of ideas, and extensive learning by the co-authors. This book is unique in the series in the relationships of the authors. This book is an example of a mentor–mentee process. The primary author is the creator of the methodology and the practice. The secondary authors are practitioners of the methodology. The primary author contributed the theory and the explanation of the models and generally served as the teacher or instructor. The secondary authors learned from the primary author and translated the theory and practice for a novice audience based on their experiences. Additionally, practitioners who have implemented the methodology and constructed Knowledge Books served as our internal reviewers. They shared their lessons learned so we could incorporate them into the methodology. We learned from the expert, tested what we learned, relearned, and formalized our learning for others.

Section 1

Engineering Critical Business Knowledge

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Chapter 1

Knowledge Engineering for Everyone

Chapter Summary

This chapter explains how and why the knowledge economy will increase the demand for knowledge engineering. It defines and traces the evolution of knowledge engineering. It identifies the two components of knowledge engineering – elicitation and representation. It discusses the increased importance of tacit knowledge, specifically know-what and know-how, for organizations and companies. The increased demand for knowledge engineering calls for increased number of knowledge engineers. Knowledge engineering will expand beyond its current homes in systems development and cognitive science. The MASK methodology is an important intermediary between formal knowledge engineering and the methods needed to develop natural language and conceptual modeling for the knowledge economy.

Why Knowledge Engineering is Critical to the Knowledge Economy

In knowledge economy, knowledge assumes a new role as an important capital asset. Knowledge is an intangible asset and thus presents challenges that do not affect physical and financial capital. Knowledge engineering is an essential capability for transforming knowledge as an intangible asset into knowledge as a capital asset. Knowledge engineering is relatively young and is still evolving as an academic field and a professional practice.

Knowledge Engineering – Definition and Characterization

The knowledge economy is so named because knowledge is the primary input, the output, and the most critical factor of production. Unlike earlier economies which were powered by physical and financial resources, the knowledge economy consumes, processes, and generates knowledge as a primary product. Knowledge is inherently human. As people live, work, communicate, and socialize, they produce, articulate, share, consume, learn, unlearn, and relearn knowledge.

The MASK Methodology and Knowledge Books, 3–22

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Each person develops a unique knowledge base over his or her lifetime. It is the knowledge bases of these individuals that fuel the knowledge economy. Knowledge is thus a valuable capital asset for organizations and businesses. Organizations and businesses must now think of and handle knowledge capital just as they do their financial and physical capital.

Knowledge is a broad idea with varied meetings. Traditionally, knowledge has been an important topic in fields such as philosophy, sociology, psychology, education, and communications. In the past 50 years, though, knowledge has been an increasingly important topic in business and economics. The knowledge sciences literature has advanced the business and economic definition and characterization of knowledge as a capital asset (Andriessen, 2004; Lafeyette et al., 2019). Knowledge is now widely accepted as a kind of capital asset. It is also widely accepted that knowledge is different from other types of capital. It has different economic properties than physical or financial capital. It is intangible, dynamic, perishable, non-excludable, and so on. In order to leverage knowledge capital for operations and business or to gain a competitive advantage in today's economy, we must have the capability to leverage knowledge. We must be able to overcome the challenges presented by its essential features. If we cannot overcome these challenges, we will not be able to identify, leverage, transfer, or preserve knowledge capital.

The past 75 years have been dominated by the rapid growth of science, engineering, and technology. These three disciplines have rapidly advanced their knowledge and their ways of working. Engineering in particular has created new methods and technologies that make work more efficient and effective. In this new world, it was logical to consider engineering as a solution to overcoming the challenges of working with knowledge to make it available, accessible, and consumable in everyday work and operations. Our initial attempts to address these challenges took the form of expert systems. The goal of expert systems was to extract the knowledge of people who had knowledge that was scarce or rare and to input it into a technical system for access and use by others.

Over the past 50 years, our efforts to build expert systems have given rise to knowledge engineering. Knowledge engineering is a young discipline. It emerged in the 1980s in the early years of computer science, particularly with the early visions of expert systems. Those early visions helped us to see what was possible, and they also gave us a glimpse into what it would take to achieve those visions. We have come a long way toward achieving those early visions. The progress has been achieved during one of the fastest economic transitions in human history. As our understanding of knowledge elicitation and representation has grown, we have expanded the field of knowledge engineering. Today, the need for knowledge elicitation and engineering is far greater than it was in the 1980s. It has outgrown the field of computer science and engineering. Today, effective and efficient knowledge engineering is critical to every aspect of the knowledge economy.

There are two components to knowledge engineering that make it possible for us to manage and leverage knowledge as a capital asset. The two critical elements are knowledge elicitation and knowledge representation. With effective and efficient knowledge elicitation and representation, knowledge becomes available,

accessible, and consumable by others across time, space, languages, domains, and cultures. There are challenges in this young field, though. Throughout time, the articulation, communication, and absorption of knowledge have presented challenges to philosophers, to communication scientists, to sociologists, to educators, and most recently to computer scientists.

The Critical Role of Knowledge Engineering in a Knowledge Economy

Knowledge engineering – when successful – addresses several major challenges presented by knowledge capital and the knowledge economy. First, the *scope and scale of knowledge production and consumption* have increased exponentially in the past several decades. The rapid growth of knowledge introduces opportunities and challenges. In the mid-20th century, the world produced the most highly educated population ever. New knowledge was produced at a higher rate than ever before. The expansion was not only one of scale but of scope. Knowledge became more specialized, took on new and more complex forms, and generated what we now refer to as expertise.

Unfortunately, businesses and organizations were so focused on creating new knowledge that little attention was paid to ensuring that knowledge was recorded, preserved, or even transferred to other humans to ensure that future generations draw from it. The absence of intentional and deliberate knowledge transfer, retention, or preservation means some of this new knowledge may be lost. In fairness to those generations, though, the tools and methods to capture or represent that earlier knowledge were immature at best or did not exist.

Second, knowledge is *essentially human* – it is embedded, embodied, embrained, and encultured in people. As a result, it is highly perishable and vulnerable to loss. People change roles, leave organizations, move, and ultimately, they are mortal. At some point, their knowledge is no longer accessible to anyone else because people are mortal. Additionally, knowledge capital is particularly prone to loss due to its peculiar economic principles and behaviors. The absence of deliberate and intentional knowledge preservation and curation strategies guarantees that valuable knowledge capital will be lost. Loss of knowledge capital is a significant economic growth and business risk for all kinds of organizations. To meet the challenge of preserving and curating new knowledge, we must expand knowledge engineering to all types of knowledge.

While all knowledge is tacit in its primary form, there are many different types of knowledge. While the typology of knowledge capital assets is broad, two are most critical to businesses and organizations – know-how (i.e., skills and competencies and procedural knowledge) and know-what (i.e., conceptual knowledge and cultural knowledge). Engineering skills and competencies knowledge require different knowledge elicitation and different knowledge representation methods. Engineering cultural intelligence and competence requires different types of knowledge elicitation techniques. As we explore the expanded scope, the difference between knowledge extraction and elicitation methods becomes clearer. Again, despite the difference in elicitation and representation requirements, the

MASK and Knowledge Book methodologies provide a consistent framework for ensuring a thorough, high-quality representation of knowledge.

Third, the rapid advance of technology has given rise to applications that have a greater capacity to acquire, consume, and leverage knowledge. Today, the knowledge we engineer is much deeper and broader in its nature. The knowledge we engineer today and in the future is much deeper and broader than it was in the 1980s when the discipline emerged. While we hear much of the representation of data and information in intelligent systems, human knowledge is the critical component that has shaped the entire course of human cognitive and social evolution (Gaines, 2013).

Fourth, the role of intelligent agents and systems is rapidly expanding in the knowledge economy. The expanding base of intelligent systems goes beyond the performance of predefined activities to knowledge transfer. They are no longer expected to perform a task instead of the expert, but to teach, to transfer their embedded knowledge. This increases the challenges of both elicitation and representation. Knowledge elicitation expands to all types of knowledge. It also requires new interfaces, that is, new forms of representation and interaction (e.g., Benysh et al., 1993). All of these applications are dependent upon knowledge engineering. They increase the demand for knowledge engineers. We must expand the population that can take at least a first pass at knowledge elicitation.

Given the breadth of tasks they support and the trust and responsibility we place in them, it is critical that the knowledge that powers them is reliable, accurate, thorough, accessible, and editable (Howell & Cooke, 1989). While machines can process higher volumes of data and information at a higher rate of speed, they offer little value if they produce errors, faulty products, and untrusted results faster that increase risk and harm. Some intelligent agents are visible, but others are not. Intelligent agents that rely on rigorous knowledge bases include intelligent tutoring and training systems, smart summarization tools, intelligent transcription systems in medical visits, medical diagnostic systems, smart Q&A systems, adaptive computer interfaces, self-driving cars, robotics, automated call centers, and wearable technologies. Each of the human activities these agents emulate is cognitively complex.

Fifth, those who are involved in knowledge engineering have expanded from world-recognized experts to individuals in organizations who are the custodians of a business' critical knowledge capital. The expanded scope is due to the shift from representing and preserving expertise to representing knowledge valuable enough to be transferred to others. Knowledge engineering can no longer be limited to those who are formally trained in engineering methods or programming. There must be a way for non-engineers to be involved in the process. We must expand our thinking about who can be a knowledge engineer. Additionally, those who do elicitation and those whose knowledge is elicited must be active in the knowledge engineering process. Over the decades, it became clear that it was cognitive scientists, psychologists, linguists, and communication professionals who had the knowledge and skills to do elicitation well. Knowledge engineering methods must be accessible to and understandable by everyone involved. Here the MASK and Knowledge Book methodology plays a critical role.

MASK methodology provides a comprehensive set of models that help guide novice knowledge engineers in both knowledge elicitation and knowledge representation. Experience has shown that these methods can create a sufficient representation to serve knowledge preservation and transfer. This book serves to guide the reader through the models and the methods and to gain a basic competence in knowledge engineering.

The demands are indeed significant. A new business capability is needed to address these demands. Organizations must actively expand their methods, techniques, and service to manage, leverage, and preserve their knowledge capital. The new business capability has expanded the demand for new forms of knowledge representation and elicitation (Gavrilova & Andreeva, 2012; Milton et al., 1999). The increased pressure for knowledge engineering creates a snowball effect on knowledge representation and elicitation competencies, methods, techniques, and services. Traditionally, the people who do knowledge engineering have been formally trained knowledge engineers. Knowledge engineers often have backgrounds in computer science, software, and database development, and an engineering specialization. The number of trained and experienced knowledge engineers is insufficient to meet the demand for knowledge engineering in the knowledge economy. It is imperative that we increase the number of these highly qualified knowledge engineers, while at the same time creating a cadre of intermediary professionals who can do the initial knowledge elicitation and representation work to design and structure knowledge boos. Over time, it is imperative to develop a basic knowledge engineering competency in all knowledge scientists and professionals.

Organizations must develop a new business capability – managing their institutional knowledge capital. The expansion increases the demand for new and more complex forms of knowledge representation. The new business capability has expanded the demand for new forms of knowledge representation and elicitation (Gavrilova & Andreeva, 2012; Milton et al., 1999). The increased pressure for knowledge engineering creates a snowball effect on knowledge representation and elicitation competencies, methods, techniques, and services. Traditionally, the people who do knowledge engineering have been formally trained knowledge engineers. Knowledge engineers often have backgrounds in computer science, software and database development, and engineering. They may also be cognitive scientists or engineers. It is simply not realistic to expect that the demand for knowledge engineering in the knowledge economy can be met by a small group of formally trained knowledge engineers.

It is imperative that we expand the population of those who are familiar with and can take a first pass at both knowledge elicitation and representation. In this context, MASK is a critical methodology, and Knowledge Books are essential knowledge representations. While grounded in well-founded theory, there is a practical aspect of MASK methodology that is understandable by most. The MASK and Knowledge Book methodology are a framework that can be used as a first pass at knowledge representation. A Knowledge Book can be handed off to a knowledge engineer or software engineer to develop a knowledge system.

Evolution and Growth of Knowledge Engineering

Knowledge engineering is the process of eliciting and representing human knowledge in a way that allows it to be used for a variety of reasons by other humans and non-humans. In the 1980s, we had a simplistic view of knowledge engineering. We assumed that knowledge engineering was a straightforward process of taking knowledge from human experts and putting it into a computer system that would be accessible to others. We assumed that if an expert's knowledge was available in an expert system it would be accessible to and consumable by other non-experts. This was a naïve assumption – it presumed that an expert's knowledge resembled a publication or procedures manual or a book. If we simply structured it in a way that a computer system could use it, it would be usable and understandable by any user. This was the early understanding we brought to the construction of what we called expert systems.

Knowledge engineering had its formal beginnings in the early to mid-1980s. We engineered knowledge to build expert systems. Expert systems are computer programs that embody domain-specific knowledge and that perform (e.g., decision making, problem solving, and design) at levels typical of human experts (but not necessarily in exactly the same manner as human experts). We expected the expert system to emulate the thinking, decision making, and performance of experts in performing an activity. The incentive to build expert systems came from (1) an increase in technological capability, (2) the growing specialization of knowledge and cognitive complexity of jobs (Howell & Cooke, 1989), (3) the interest in creating artificial intelligence in machines, and (4) the cost inefficiencies and risks of alternative general problem-solving approaches (Feigenbaum, 1989). The architectural design of expert systems emulated how we thought experts went about solving problems and performing an activity (Simon & Newell, 1971) (see Fig. 1). We sought a design that could be used in a range of problem-solving contexts and one that

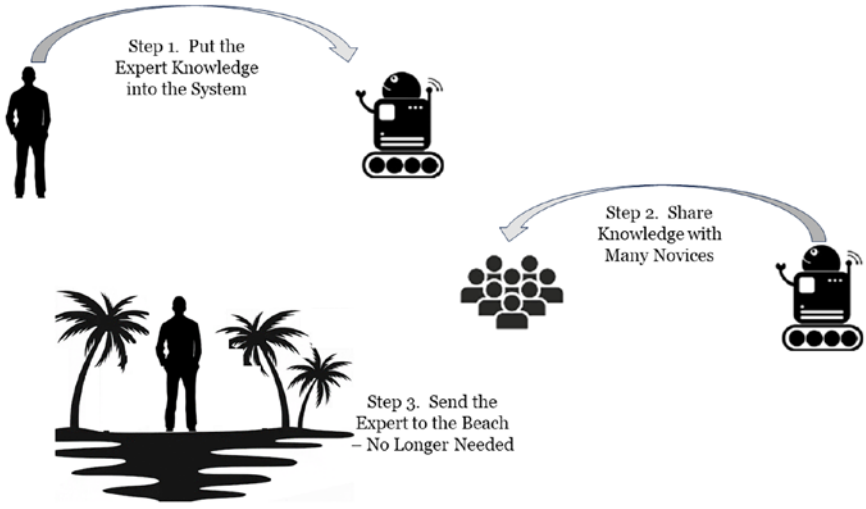

Fig. 1. Early Visions of the Role of Expert Systems.