Creative International and Online Education - Volume 2

The Fundamentals of Systems Thinking, Management & Effective Leadership

Sławomir Wyciślak
Michael A Radin

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About the Authors

Michael A. Radin earned his Ph.D. at the University of Rhode Island in 2001 and is currently an associate professor of mathematics at the Rochester Institute of Technology. Michael is also an international scholar at the Riga Technical University Department of Engineering Economics and Management, at the Yuriy Bugay International & Scientific Technical University in Kyiv, Ukraine, at the Jagiellonian University and at WSEI in Krakow, Poland and at the University of Foggia in Foggia, Italy.

Michael taught the SAT, GRE, and GMAT preparatory courses and a variety of undergraduate- and graduate-level courses and conducted research projects with undergraduate and graduate students. Michael also has intensive international pedagogical experience. Exploration of Michael's international frontiers commenced with his first sabbatical at the Aegean University in Greece during the spring 2009 semester. Michael designed and taught a graduate-level course on difference equations. During his spring 2016 sabbatical, Michael designed and taught courses and seminars, such as discrete mathematics, difference equations with applications in robotics, and introduction to photography, at the University of Latvia, Riga Technical University, Transportation & Sakaru Institute, and the University of Liepaja in Latvia.

Michael enjoys writing textbooks and considers it a hobby. Michael wrote several mathematics textbooks, including one on international and online education. He is currently a series editor for the World Scientific Publishing Company and enjoys guiding authors in writing textbooks.

Michael designed and conducted a seminar on "Developing International Research Coalitions" at Riga Technical University Doctoral School and designed and conducted a "Risk Management Seminar" at Riga Technical University Department of Engineering Economics and Management. Michael also developed and taught a course on "Introduction to Business Start-Ups" at the Yuriy Bugay International & Scientific Technical University in Kyiv, Ukraine, Optima Online School in Ukraine, and the Jagiellonian University in Krakow, Poland.

Recently, Michael designed and taught an online course on "Introduction to Recognition of Patterns" at WSEI in Krakow, Poland. He developed and taught this online course from his textbook on *Analyzing Mathematical Patterns — Detection & Formulation.*

Michael gained valuable experience teaching online courses at RIT, such as freshman calculus courses, discrete mathematics courses, complex variables, and graph theory. While teaching online courses, Michael developed new teaching tactics, such as posting course notes and videos prior to lectures, posting recorded lectures and prompt and guided graded feedback, and offering extensions on homework assignments and multiple resubmissions of homework assignments. These methods proved to work very successfully for him and his students, kept the students stimulated and engaged, and improved their course performance (Radin and Riashchenko, 2017; Orlova and Radin, 2018). Michael's aim is to make mathematics, online, international, and interdisciplinary education accessible to everyone and inspire students to learn.

Michael enjoys traveling and spending time abroad, getting acquainted with new cultures and academic systems, participating in local and regional conferences, and designing and teaching new seminars and courses. Michael is especially interested in developing new pedagogical innovations and practices, both domestically and internationally, and comparing the similarities and differences among them.

During his spare time, Michael spends time outdoors and is an avid landscape photographer. In addition, Michael is an active poet and has several published poems about nature in the LeMot Juste. Furthermore, Michael published an article on "Re-Photographing the Baltic Sea Scenery in Liepaja: Why photograph the same scenery multiple times" in the *Journal of Humanities and Arts* in 2018. Michael also recently published a book, *Poetic Landscape Photography*, with JustFiction in 2019. Spending time outdoors and doing active landscape photography have helped widen Michael's horizons about nature's patterns and cadences.

Sławomir Wycislak, Ph.D., is an associate professor in the Department of Quality Management at the Institute of Economics, Finance, and Management at the Jagiellonian University in Kraków, Poland. His research, publications, and teaching activities focus on examining complexity science, system approach applications in social science, digital technologies' implications for complex systems, risk management, and supply chain management. He currently specializes in the navigation of digital platforms. His research is oriented toward applying systems thinking to solving complex issues, in particular, exploring the implications of complexity for digitization and researching the contagion effect in complex systems. His recent studies applied the paradox theory to accurately understand decision-makers' behaviors during the unexpected and chaotic changes occurring in our complex world.

Parallel to his academic career at the Jagiellonian University, Sławomir gained industrial working experience at Unilever. He directed projects and implemented lean and agile practices to achieve the logistics requirements of internal and external customers. He worked on digitization projects across the European inbound and primary transportation networks of Unilever.

Prior to his tenure at Unilever, Sławomir expanded his skills and experiences as a research analyst at Euromonitor International. He played a vital role in strategic analysis and forecasting in numerous sectors, such as FMCG, consumer health, and consumer food service. His strong experience and passion for nurturing strong industrial relationships and delivering data-driven insights significantly enriched Euromonitor's market research capabilities.

Sławomir began his professional journey in the IT sector by demonstrating efficient and proficient skills in handling challenging tasks. These tasks include customization, change management, and the deployment of the computer telephony system for nearly four years.

His unique combinations of industrial and academic experiences, together with his versatile skill set, present him with unique opportunities to explore and blend the intersection of theory and practical applications in an ever-evolving business and academic landscape. Furthermore, Sławomir expanded his international horizons and expertise as a lecturer at the University College Cork and the Ruhr University Bochum. In fact, he conducted engaging seminars on "System Science: A Dynamic Tool for Understanding the Complex World," contributing to a global understanding of his field.

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Rochelle's recommendations were very instrumental in writing our welcoming story and presenting the vital characteristics of systems thinking and their applications. These include problem-solving techniques, analytical skills, comparison skills, interpreting internal and external feedback and influences, and understanding complexity.

We would like to thank the reviewers for their meticulous observations and suggestions while reviewing the book. Their vigilant comments were very useful and enhanced the book's contents and interrelations between the topics. Their prudent recommendations revealed new ideas for future textbooks.

We would like to extend our appreciation to the Faculty of Management and Social Communication, Institute of Economics, Finance, and Management at the Jagiellonian University for providing us with essential support, including the infrastructure and academic environment, while writing this book. We acknowledge the institute's professionalism and commitment to fostering the research and intellectual pursuits that ensured a conducive space for this endeavor and guided our innovative ideas in writing this book.

In addition, we would like to take the opportunity to thank Joanna Klinger-Krizar at the Jagiellonian University Journalism, Media and Social Communication Institute Faculty of Management and Social Communication for her support and encouraging new themes, for guiding us in the right direction, for providing us the resources, for persuading us and other colleagues at the Jagiellonian University to write books on creative and innovative themes, and for enhancing international collaborations.

Our interactions with various colleagues in these institutes at the Jagiellonian University significantly contributed to making our journey of composing this book a comprehensive and enriching learning experience. This especially emphasized the inception, progression, and culmination of our innovative ideas encapsulated in this book.

Contents

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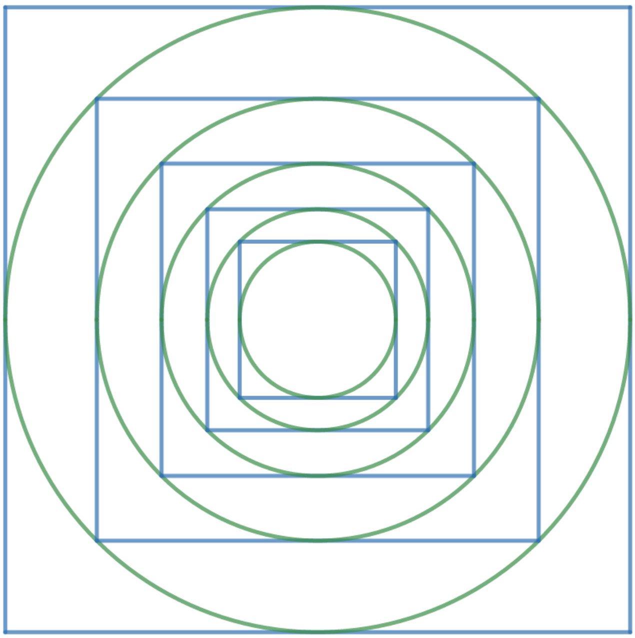
Introduction

Welcome to the world of systems thinking. How can we apply the fundamentals of systems thinking to management, leadership, complexity, diversity, and problem-solving? We begin with presenting the unique characteristics of these fundamentals, which especially include their applications and implications. We study their features as individual components and as a system which consists of combinations of their interactions. In particular, we discover the interconnections between these attributes and diversity. We examine how and why these interconnections and attributes can impact management and education advances.

How are systems thinking, management, leadership, complexity, and diversity interconnected with each other? The answer to this question will pave a new path to understanding the impact of systems thinking while overcoming biases in your thought processes. Systems thinking tools include causal loops, stocks and flows diagrams, the iceberg metaphor, and a rich picture resembling the applications of systems thinking in management and education. We include case studies to demonstrate the implications of systems thinking that are beneficial for management and education.

We reveal how the fundamentals of systems thinking, leadership, complexity, and diversity pave strong two-directional, cross-cultural, and cross-disciplinary communication between participants and how they welcome equity, inclusion, and collaborative learning. We describe how systems thinking, management, leadership, and complexity promote cross-cultural and cross-disciplinary collaborations and hence stimulate highly beneficial feedback that expands your comfort zones, experiences, and intuitions and leads you to new collaborations and innovations. These traits are essential to stimulating, amiable, and trustworthy teaching, learning, and working environments.

In geometry, for instance, there are fractal patterns that emerge while assembling a system of diminishing squares and circles, as seen in the following diagram:



We invite you to join us on our journey of discovery that examines and designs new systematic schemes, structures, and formulations. Learning and incorporating systems thinking will develop important cognitive skills, new problem-solving techniques, and efficient two-directional communication. Using a systems thinking approach will guide you in detecting the similarities and contrasts between different systematic arrangements that can naturally emerge. A systems thinking approach can be used to develop systematic schemes for detecting mistakes and missing fragments. These systematic schemes then lead to making revisions and improvements and to discovering new orientations. Furthermore, we present recommended systematic schemes for understanding concepts, effective leadership, cognitive skills, comparison skills, and problem-solving techniques. These will then prepare you to design your own systematic outlines that lead to accomplishing the desired goals and to new orientations and innovations.

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Chapter 1

Management and Systems Thinking

Our aims are to present the principles of systems thinking, the fundamentals of management and leadership, the history of management theories, the rudiments of complexity, the pearls of diversity, equity, and inclusion, and the motivations for creativity and innovation. We also aim to discover the interconnections between these concepts and to discover how the principles of systems thinking blend together with the fundamentals of management, leadership, and complexity and lead to diversity and creativity. Furthermore, we develop a systematic scheme to understand the individual concepts, the similarities and contrasts between them, and the connections among them. Section 1.1 will present the principles of systems thinking and the key contributors to this field.

1.1 Systems Thinking and Key Contributors

Systems thinking is a holistic approach to analysis that focuses on the system's components. The systems thinking approach explores how each component of a system works individually and how components of a system interact with each other. This approach blends individualized and collaborative learning. Systems thinking also examines how a specific system functions over time and as a subsystem of a larger system. A systems thinking approach can be applied to various research fields, such as medical, environmental, political, economic, human resources, and educational.

Systems thinking consists of **analysis** and **synthesis**. Analysis focuses on structure and reveals how the system works. Synthesis, on the other hand, focuses on functioning and unfolds why the system works. Analysis and synthesis are critical fundamentals and are complementary to each other. In fact, analysis delves deductively into the system's characteristics, while synthesis inductively expands and examines the system's environment (Ackoff, 1999). Stave and Hopper's definition examines the following features of the systems thinking approach and process (Stave and Hopper, 2007):

1. Recognizing interconnections,
2. Identifying and interpreting feedback,
3. Understanding dynamic behavior,
4. Differentiating types of flows and variables,
5. Using conceptual models,
6. Designing simulation models,
7. Testing policies (Arnold and Wade, 2015).

The goal of systems thinking is to promote a holistic and integrated view of problems and challenges while encouraging collaboration and cooperation across boundaries and discovering more effective and sustainable solutions. Next, we focus on the history and evolution of systems thinking. These include motivations, applications, innovations, and benefits. Section 1.1.1 outlines Peter Senge's contributions.

1.1.1 *History and evolution: Peter Senge*

Peter Senge is a prominent management theorist and a leader in the field of systems thinking. He is the founder of the **Society for Organizational Learning**, a senior lecturer at the MIT Sloan School of Management, and a co-faculty member at the New England Complex Systems Institute. According to Senge, systems thinking is a discipline that emphasizes the interconnectedness and interrelationships between elements within a system rather than looking at individual components in isolation.

In his book *The Fifth Discipline: The Art and Practice of the Learning Organization*, published in 1990, Peter Senge defined systems thinking as "a way of understanding the complexities of life and the world, that recognizes the interconnected and interrelated nature of things." Peter Senge advocates for the use of the systems thinking method to get companies acquainted with organizational learning and to transform companies into learning organizations. The diagram in Figure 1.1 presents the five fundamentals of the "Fifth Discipline" and illustrates Peter Senge's Systems Thinking Learning Cycle.

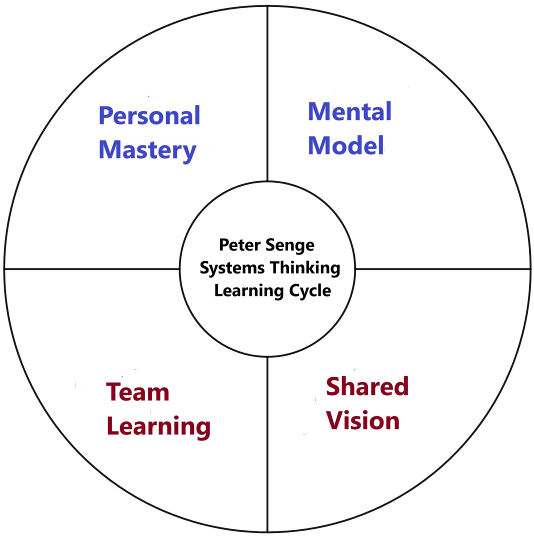


Figure 1.1. Peter Senge's systems thinking learning cycle.

In Figure 1.1, first note that personal mastery and the mental model focus on individualized learning, while building shared vision and team learning focus on collaborative learning. Second, observe that systems thinking integrates personal mastery, the mental model, building shared vision, and team learning together and composes Peter Senge's Systems Thinking Learning Cycle.

Personal mastery assembles a set of specific principles and practices that enable a person to learn, design a personal vision, and widen global horizons. Personal mastery also develops and enhances self-awareness. Self-awareness then leads to understanding the principles of emotional intelligence, identifying strengths and weaknesses, and effectively managing relationships.

Mental models highlight the fundamentals of metacognition, which is defined as the awareness and understanding of knowledge and self-regulation of one's own thought and cognitive processes. Metacognition is also oriented toward learning how to learn, learning how to think, and thinking how to think. In particular, awareness focuses on developing the fundamental base of knowledge and the expansion and improvement of knowledge. Mental models enhance personal awareness and influence what we see and how we act (Senge, 2006). Mental models commence with individualized learning and gradually transition to collaborative learning.

Shared vision naturally arises when a learning organization sets out to achieve specific goals. Then, each individual within the organization does his/her best to achieve the desired goal. Shared vision blends individualized and collaborative learning while working on achieving the assigned tasks.

Team learning is a special collaborative learning technique that focuses on emergent learning to successfully adapt to rapid and unexpected changes while reaching shared goals in a dynamic and competitive environment. Peter Senge emphasizes the following three key features of team learning:

1. Working as a team in widening and revising global outlooks and providing constructive and supportive feedback and recommendations on global interpretations;
2. Spontaneous teamwork oriented on adapting to sudden and unexpected changes while designing an amiable and trustworthy working environment;
3. Two-directional communication and exchange of ideas among the teams and adapting, promoting, and implementing new practices.

In particular, Senge views systems thinking as a framework for understanding patterns of change and recognizing that the behavior of a system is influenced by its structure and feedback loops. Senge also highlights the importance of developing an intuitive understanding of systems instead of solely relying on formal education and training. He asserts that individuals who are successful in handling complex systems have an innate ability to see the interconnections and interrelationships within a system and are able to navigate its complexities effectively.

Senge's work has significantly impacted the fields of management and systems thinking, and his ideas continue to be widely cited and applied in both academia and industry. According to Senge, systems thinking should help with dealing with dynamic complexity. Senge also claims that the dynamic complexity involves "situations where cause and effect are subtle, and where the effects over time of interventions are not obvious" (Senge, 2006). Supplemental details on learning organizations and organizational learning are discussed in Sections 6.4.2 and 7.4.

1.1.2 *History and evolution: Donella Meadows*

Donella Meadows (1941–2001) was a professor of environmental studies at Dartmouth College and a very active American environmental scientist, educator, and writer. She is also the author of the books *The Limits to Growth* and *Thinking in Systems: A Primer*. Meadows defined systems thinking as "a way of looking at problems and opportunities in a holistic and integrated manner, taking into account the interrelationships and interdependencies between the various elements and factors involved" (Meadows, 2008). In her book, Meadows provides a comprehensive introduction to systems thinking, including its underlying principles and methodology as well as practical tools and techniques for applying systems thinking to real-world problems. She reveals the importance of considering the big picture and the relationships between elements when solving problems, as well as the need for systems thinking in order to achieve sustainable, long-term solutions.

Donella Meadows' definition of systems thinking unfolds the holistic and integrated nature of the approach. This specific approach analyzes problems and opportunities in a systemic way, where the systems thinking method assumes the interrelationships and interdependencies between the various elements and factors involved. It considers how changes in one part of a system may impact other parts and how these relationships shape the behavior of the system as a whole.

To promote and stimulate transitions to sustainable systems at all levels, ranging from local to global, Meadows established the **Sustainability Institute** in 1996. The pyramid-shaped diagram in Figure 1.2 illustrates the features of Meadows's sustainability model.

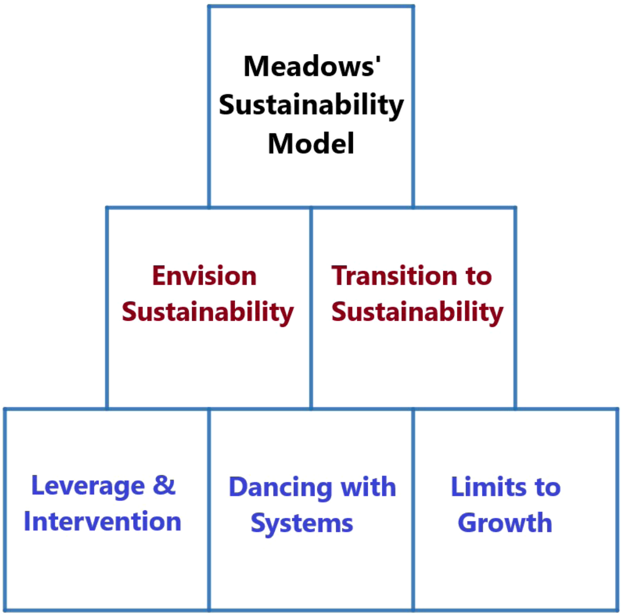


Figure 1.2. Meadows' sustainability model.

Envisioning a Sustainable World is a powerful speech by Meadows in 1994 that outlines the crucial role that visioning plays in designing the sustainable world we desire to live in.

In **Transition to Sustainability**, Meadows describes how visioning, networking, truth-telling, and learning are pertinent fragments in the quest for sustainability.

Leverage Points and Intervention clarifies and confirms Meadows' deep wisdom on how systems work and how to revise systems to produce influential and beneficial changes.

Dancing with Systems emphasizes the importance of managing, regulating, and adjusting systems after significant changes occur, as well as the significance of flexibility and adaptation.

Limits to Growth investigates the patterns and dynamics of human presence on Earth, with a specific focus on the environmental and economic aspects.

1.1.3 *History and evolution: Russell Ackoff*

Russell Ackoff (1919–2009) was an American organizational theorist, consultant, and Anheuser-Busch Professor Emeritus of Management Science at the University of Pennsylvania Wharton School. Ackoff was the chair of the **Institute for Interactive Management**. He was an active cross-disciplinary researcher and explored the fields of operations research, systems thinking, and management science. In 1957, Ackoff published a book on *Introduction to Operations Research*, together with C. West Churchman and Leonard Arnoff.

During the 1970s, Ackoff was one of the dominant critics of "technique-dominated operations research." Russell Ackoff was very active in the U.S. and served as the president of the Operations Research Society of America (ORSA) from 1956 to 1957. In addition, he was also the president of the International Society for the Systems Sciences (ISSS) in 1987.

Russell Ackoff defined systems thinking as "a way of thinking about, and a language for describing and representing, the forces and interrelationships that shape the behavior of systems." (Ackoff and Emery, 1972; Ackoff, 2004). In particular, Ackoff's definition of systems thinking emphasizes the importance of the interrelationships and interdependencies between the different components that make up a system. Ackoff's definition highlights the essence of understanding the relationships in order to effectively address complex problems by thoroughly examining the forces that describe the specific behavior of a system.

In his book *Redesigning Society*, Ackoff applies systems thinking to a wide range of societal problems, such as poverty, crime, and environmental degradation. In fact, he concluded that these problems cannot be effectively addressed and solved by applying a fragmented approach. He then claimed that a more holistic and integrated approach is essential to effectively understand and solve these challenging problems with detrimental consequences.

Ackoff's systems thinking approach reveals the necessity of understanding the root causes of complex problems and thoroughly determining solutions that address these root causes. This then requires a deep understanding of the relationships between different elements of a system and the ability to see how changes in one part of the system can impact other parts of the system.

Overall, Ackoff's definition of systems thinking highlights the significance of the relationships between the components of a system, especially by considering the interrelationships and interdependencies that describe the behavior of systems. By focusing on these relationships, Ackoff's approach to systems thinking provides a valuable framework for addressing complex problems in a holistic and integrated manner.

1.1.4 *History and evolution: Peter Checkland*

Peter Checkland is a British management scientist and emeritus professor of systems at Lancaster University. He established the **soft systems methodology** (SSM). This methodology is based on the fundamentals of systems thinking and systems practice. Systems practice guides to uncovering an optimal solution within complex environments, thus leading to a thorough interpretation of the system, which requires adaptation to changes in the environment. His research significantly contributed to the data science and change management disciplines (Checkland, 1981).

In his book *Systems Thinking, Systems Practice*, Peter Checkland defines systems thinking as "a way of viewing the world that emphasizes the interconnections and interrelationships between events rather than viewing them individually" (Checkland, 1981). This book is considered one of Checkland's most creative and influential works and provides an overview of his SSM approach to systems thinking. His perspective recognizes that global events are interconnected and that the behavior of any event is influenced by the relationships it has with other events.

Analogous to Russell Ackoff, Checkland's definition of systems thinking also emphasizes that the interconnections and interrelationships between events are essential. This perspective recognizes that global events are interconnected and that the behavior of any one event is influenced by the relationships it has with other events.

1.1.5 *Fundamentals of systems thinking*

The fundamentals of systems thinking develop and enhance our problem-solving abilities within complex and diverse systems. System theory, or systems science, unfolds the cross-disciplinary and cross-cultural study of systems, where system thinking can be introduced, taught, and enhanced. The systems thinking approach assumes that a system is an entity with interrelated and interdependent components. In fact, a system is defined by its boundaries and, at times, can be more than the sum of its components. Revising or changing one component of the system will often affect other components as well as the entire system.

The primary aim of systems thinking is to develop systematic discovery methods to determine the system's dynamics, constraints, conditions, and assessment methods that can be discerned and applied to accomplish the optimized equifinality (Beven, 2006). The diagram in Figure 1.3 reveals the three streams of systems thinking:

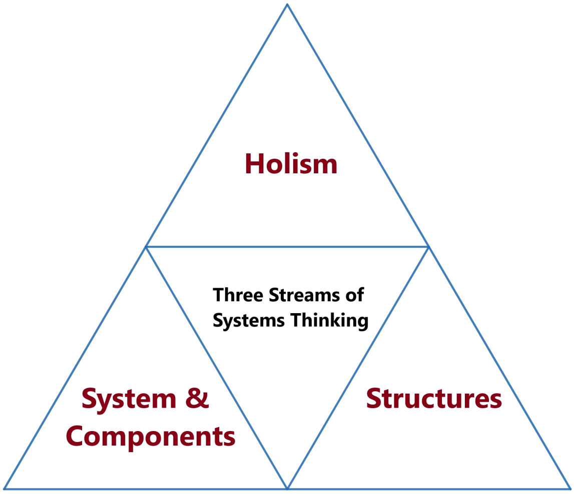


Figure 1.3. The three streams of systems thinking.

Holism assumes that various systems should be viewed as a whole instead of isolated fragments. Holism focuses on synthesis or induction. Jan Smuts analyzed and described holism in his book *Holism and Evolution* in 1926.

A system is assembled into **components** that are interconnected with each other inside a boundary that defines the system as a whole. The study of individual components focuses on analysis or deduction. In fact, a component of a certain system may be a sub-system of the entire system. This then leads to a significant emphasis on the part–whole relationship. System dynamics can be viewed in terms of receiving inputs and transforming them into outputs (Ackoff and Emery, 1972).

Structures are an essential characteristic of a system, as they are applied to assemble individual components and the entire system as well. For instance, social structures can be viewed as a set of defined individual or shared responsibilities to conduct certain tasks and achieve specific goals. A social structure can be interpreted as a set of social arrangements that are both emergent from and determinant of the actions of individuals (Olanike, 2011). Social structures substantially affect larger systems, such as educational systems, legal systems, financial systems, economic systems, and political systems.

1.1.6 *Critical systems thinking*

Critical systems thinking (CST) is a systems approach designed to guide decision-makers and stakeholders to solve and improve complex and diverse problem situations that often occur at cross-disciplinary levels. These often include cross-departmental, cross-organizational, and cross-cultural boundaries.

CST views systems thinking as a vital tool for managing complexity and multidimensional problems that involve the interaction of technical, economic, organizational, human, cultural, and political aspects. CST unfolds positive critical traits as it aims to maximize the strengths of existing approaches within the assigned constraints and limitations.

CST also gravitates toward the synergy effect. The **synergy effect** is the result of two or more interactions that produce an effect that is greater than the cumulative effect. CST encompasses variety and diversity, as these two are essential for survival. More details on the synergy effect are discussed in Section 9.4 of Chapter 9.

The diagram in Figure 1.4 illustrates the rudiments of CST.

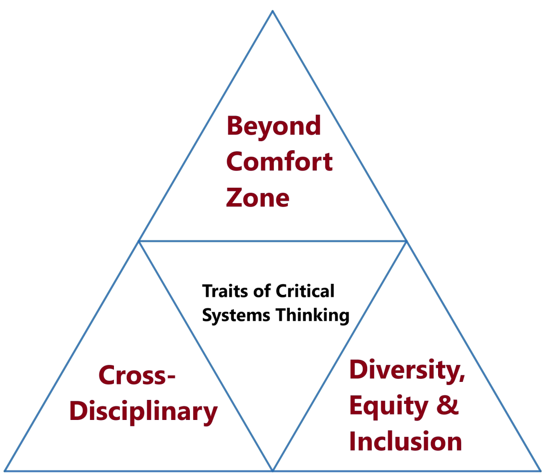


Figure 1.4. Rudiments of critical systems thinking.

CST is a method of viewing complex systems that goes **beyond the comfort zone** and beyond traditional systems thinking. In fact, it examines the relationships between power, oppression, and the behavior of complex systems. In particular, it assumes the social, political, and economic factors that shape the behavior of systems and recognizes that these factors can often result in unjust outcomes. A thorough study of complex systems leads to the rudiments of emotional intelligence.

CST aims to challenge and change the existing power structures and promote more **diverse, equitable, and inclusive systems**. Organizations realize that efforts toward diversity, equity, and inclusion produce beneficial results. The aims are to stimulate self-awareness, cultural competency, and empathy in employees while addressing unconscious bias as well as promoting an amiable and trustworthy environment. This leads to the assumption of factors that influence complex systems' behavior while designing solutions that address both the technical and social aspects of problems.

CST focuses on linking **cross-disciplinary** interrelations and interdependencies, such as political science, sociology, economics, education, and environmental studies. This presents many factors to assume that influence the complex systems' behavior and help develop solutions that address both the technical and social aspects of problems.

CST has been applied to a wide range of complex problems, such as environmental issues, social inequality, and political conflict. By assuming the power relationships and underlying causes of problems, CST can help develop more equitable, sustainable, and effective solutions. CST supports numerous systems approaches, such as systems engineering, system dynamics, organizational cybernetics, soft systems methodology, and critical systems heuristics.

Michael C. Jackson wrote a book titled *Critical Systems Thinking and the Management of Complexity*, in which he shares the following quote: "We can conclude that Critical Systems Thinking is a transdiscipline that advocates the appropriate use of a broad range of methods as appropriate to a specific problem. It is a transdiscipline that deals with the use of range of methods, rather than being just another single method. And that is why it is so valuable. It appreciates the value in the diversity of the other methods" (Jackson, 2019).

W. Ross Ashby (1903–1972) was an English psychiatrist and a pioneer in cybernetics. In his first law of cybernetics, also known as the law of requisite variety or **Ashby's Law**, Ashby stated: "In order for a system to survive, it must have equal or higher variety than the surrounding environment" or claimed, "In order to deal with the world around us, we need a repertoire or responses that are equal to or greater than the problems we face." More attributes of Ashby's Law are discussed in Section 2.5.2.

1.1.7 *Systems thinking and applications*

Systems thinking has numerous applications as it thoroughly examines each fragment individually, the interrelations between the fragments, and how they affect each other and the entire system as well.

For example, **Toyota** has been applying the systems thinking approach to various aspects of its operations for many years. One of the key applications of systems thinking at Toyota is in its production system, known as the Toyota Production System (TPS). TPS is a set of principles and practices aimed at improving efficiency, reducing waste, and enhancing quality in the production process. TPS reveals a holistic and continuous improvement approach and involves all the employees in the organization, from the factory floor to the management team.

Toyota also applied the systems thinking approach to its product development process. The company has a well-established process of incorporating customer feedback and market research into its product development decisions. This approach helps Toyota ensure that its products meet customer needs and preferences.

Systems thinking focuses on inductive and deductive reasoning. The diagram in Figure 1.5 outlines the scheme of systems thinking applications.

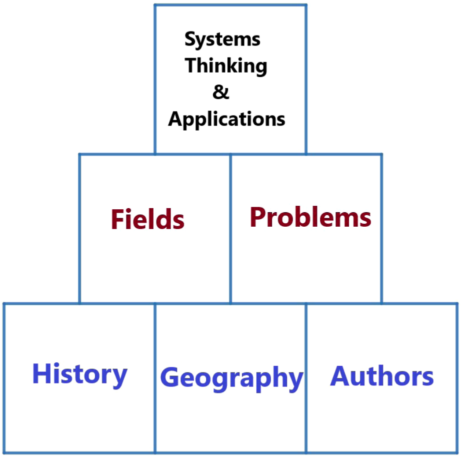


Figure 1.5. Systems thinking applications.

Systems thinking has been applied in numerous **fields**, such as management, business, healthcare, engineering, economics, education, international relations, environmental science, organizational behavior, project management, quality improvement, and sustainable development. For instance, systems thinking is a vital tactic in management and business, applied to improve organizational efficiency and decision-making, with practical applications in total quality management, organizational design, and learning organization.

The fundamentals of systems thinking offer **engineers** and **managers** opportunities to design more efficient schemes by considering all aspects of their products' environment prior to assembling them. These principles present more flexibility and prepare them to anticipate certain potential problems early in the process, which then saves time and money in the long-run when unforeseen issues emerge.

In **healthcare**, systems thinking has been used to improve patient outcomes and the quality of care, with practical applications in areas such as patient safety, care coordination, and health outcomes improvement. In addition, the principles of systems thinking aim to reduce waiting lines for patients, enhance the accuracy and precision of diagnoses, and present better accessibility to public health.

In **education**, systems thinking has been applied to improve the quality of teaching and learning, with practical applications in areas such as student achievement and teaching effectiveness.

The systems thinking approach is effective in **environmental science** to accurately and precisely understand and address complex environmental problems, such as sustainability and ecosystem management.

Governments use the system thinking approach to frame policies with long-term implications that consider multiple factors, such as economic growth and social welfare.

The fundamentals of systems thinking can be used to solve, manage, and prevent a wide variety of **problems**. Within complex problems, the main implication of the systems thinking approach is to identify and manage potential risks and reduce the magnitude of consequences. This offers strong and reliable control over the given environment while creating new problem-solving approaches.

Historically, the fundamentals of systems thinking have been developed and applied since the mid-20th century, in particular, a growing emphasis on addressing complex problems. During the past several decades, systems thinking has evolved and grown while incorporating new ideas, methodologies, and technologies. For instance, technological advances have enabled computer simulations and models to better understand complex systems and make more accurate decisions. This then led to the development of new applications of systems thinking in management and environmental science. Furthermore, the growing interest in sustainability and environmental stewardship led to the increased and enhanced application of systems thinking.

Geographically, the fundamentals and applications of systems thinking expanded globally in numerous countries. In Japan, systems thinking has been applied in the development of total quality management. In the meantime, the United States has applied systems thinking in management and environmental science and in its Department of Defense. The global expansion of the principles of systems thinking reflects its versatility and practicality as it can be applied to a wide range of complex problems.

Numerous **authors** have studied systems thinking and contributed to it. These include William Edwards Deming, Russell Ackoff, Peter Senge, Jay Forrester, Ludwig von Bertalanffy, Fritjof Capra, and Donella Meadows. Each one of these authors has contributed his/her own unique perspectives and insights to the field. W. Edwards Deming's work on total quality management had a significant impact on management and business, while Peter Senge's work on learning organization has been influential in the fields of education and organizational development.

1.2 Management and Leadership Traits

The following quotes portray equity, diversity, inclusion, individualized learning, collaborative learning, effective two-directional communication, efficiency, and systematic structure as the essential characteristics of effective management:

> "Management is the art of getting things done through the other peoples." — Mary Parker Follett.
>
> "Management is knowing exactly what you want the workers to do, and then seeing that they do it in the best and cheapest way." — Frederick Taylor.
>
> "Management is about arranging and telling. Leadership is about nurturing and enhancing." — Tom Peters.
>
> "Leadership is all about emotional intelligence. Management is taught, while leadership is experienced." — Rajeev Suri.

The word "management" first originated from the Latin word *manus* (meaning "hand"). It also arose from the Italian word *managgiare* (meaning "to handle"). **Management** can be interpreted as handling and guiding. The diagram in Figure 1.6 outlines the fundamental characteristics of management.

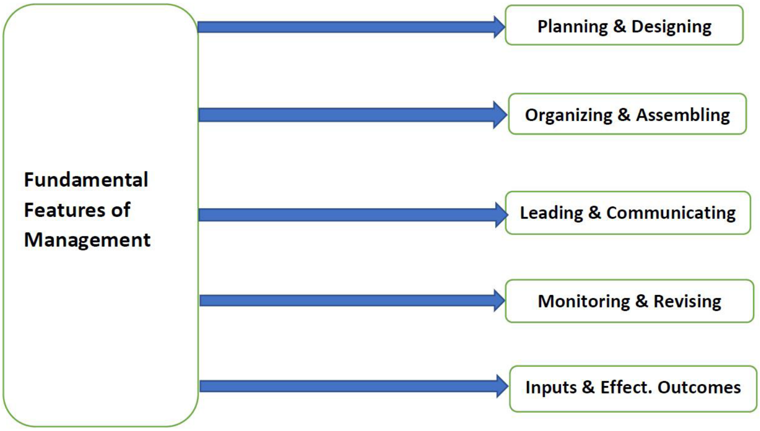


Figure 1.6. Fundamentals of management.

We begin with **planning and designing** to lay the foundation of what the goals are and which strategies and resources will be most effective in accomplishing them.

This is often done with charts, diagrams, and outlines that describe the schemes of specific goals and the corresponding strategies.

Organizing and assembling create an amiable, trustworthy, and collaborative working environment to accomplish the desired goals.

This strategy outlines all the necessary fragments of a system, the ordering of the fragments, and the connections between the fragments. A guided and systematic scheme represents a graphical presentation of a specific concept or method and how it is applied.

Leading and communicating inspire, stimulate, and influence people to develop effective two-directional communication skills while working to accomplish the assigned tasks.

Effective leadership and communication establish trustworthy relations and retain a positive attitude and motivation while paving the path to the assigned destination.

Monitoring and revising will aid in detecting mistakes and missing fragments by making revisions while paving the individualized learning path to success.

Providing supportive, positive, and guided feedback during the process is essential. A healthy working atmosphere will provide positive and rewarding feedback instead of negative and punitive feedback.

Navigating participants to successful outcomes is one of the most important managerial tasks, as it outlines the quality of managerial skills of an individual or organization. Significant efforts into input are essential to produce successful outcomes: “There’s no reward without work, no victory without effort, no battle won without risk” (Nora Roberts, 2003).

The fundamentals of management are important tools that aid individuals and organizations on achieving their primary objectives efficiently. Developing effective two-directional communication that will minimize time, costs, and the use of resources and participants helps achieve effectiveness. Section 1.2.1 outlines the history of the development of management and its contributions to it.

1.2.1 *History of management*

Management especially played a critical role in organizational planning and structure during the industrial revolution. In particular, the managerial role directs its focus on maximizing efficiency while minimizing costs. Successful management aims to design and present a schematic structure and apply it to handle challenges effectively and smoothly.

Frederick Taylor (1856–1915) was an American mechanical engineer. He was well known for his methods for enhancing industrial efficiency. He was one of the first management consultants. He is often referred to as the “Father of Modern Management.” In 1909, Taylor described his efficiency techniques in his book *The Principles of Scientific Management*. This book presented Taylor’s fundamentals of scientific management, or industrial-era organization and decision theory. He strongly believed in scientific management, as it indicates the use of scientific methods to examine and optimize the assigned production tasks with increased efficiency (Epstein, 1996).

In particular, Taylor's principles highlight efficiency by decomposing the designated task into smaller and simpler tasks. This introduced quicker performance with maximum efficiency. Taylor also developed and enhanced **task specialization**. This principle focuses on increased structure and on specializing and becoming an expert in specific tasks, which leads to increased productivity. In addition, Taylor believed that providing specific guided instructions to employees and rewarding them for their efforts were essential factors in determining productivity. This practice paved the individualized learning path while retaining an amiable working environment (Bedeian and Wren, 2001).

Taylor introduced bonuses or extra pay to the workers who exceeded their quotas, achieved specific goals, and went beyond the expected outcomes. Taylor's innovative ideas in management are still practiced today by numerous organizations as they improve working and production efficiencies.

Furthermore, Taylor established **industrial engineering**. In fact, industrial engineering examines managerial issues such as the optimization of complex processes and systems and revising and implementing integrated systems of people, money, knowledge, information, and equipment. As a consequence of his substantial achievements and contributions, scientific management is occasionally referred to as **Taylorism**, as described in his book, *The Principles of Scientific Management.*

Henri Fayol (1841–1925) was a French mining engineer, mining executive, author, and director of mines, who developed a general theory of business administration, known as **Fayolism**. Analogous to Frederick Tyalor, Henri Fayol is also known as the "Father of Modern Management." He devoted his studies to administrative theory, the structure of organizations, and organizational operations.

Fayol published his book, *Administration Industrielle et Générale*, in 1916, at the same time that Frederick Taylor published his book on the principles of scientific management. In his book, Fayol proposed 14 principles that describe the efficiency of organizations, which include the unity of command, division of labor, scalar chain, subordination of individual interests to general interests, remuneration based on merit and equity, centralization or decentralization, order, authority, and responsibility.

Fayol's innovative principles of management focused on people instead of machines or production processes. He argued that it is essential to treat workers fairly with respect while stimulating equity, diversity, and inclusion. These include proper training and offering good wages.

He also believed that managers should develop amiable and trustworthy relationships with their employees so that they could communicate comfortably and effectively with each other. As a result of Fayol's innovative management ideas, effective, amiable, and two-directional communication between employers and employees greatly improved throughout Europe during the 20th century.

Fayol developed the following five essential elements of business strategy and planning: forecasting, organizing and staffing, directing, coordinating, controlling, and budgeting. Numerous organizations apply Fayol's five elements of business strategy in the general theory of management as a framework for planning their future successes (Narayanan and Nath, 1993). Fayol also developed supplemental methods for operational decision-making. This includes marginal analysis, which is still widely used in various industries (Fayol, 1917). Fayol also proposed the following six types of organizational activities: technical activities, commercial activities, financial activities, security activities, accounting activities, and managerial activities (Voxted, 2017).

Fayol's works profoundly impacted how businesses were managed during the 20th century and continue to shape how business operations are managed today. His innovative methods led to the design of a standardized approach to managing organizations.

Max Weber (1864–1920) was a German sociologist, historian, jurist, and political economist. Weber also specialized in **personality charisma**, or **charismatic authority**, and is recognized as one of the fathers of sociology. He studied and published influential texts on bureaucracy, authority structures, economic sociology, and religious analysis. His theories focused on understanding and connecting the relationships between power, authority, and social stratification (Tiryakian, 2009). These fundamentals then navigate to the principles of systems thinking.

In *Verstehen* ("to understand" in German), Weber especially underlined the contrasts between objectivity and subjectivity ("Verstehen: The Sociology of Max Weber", 2011). Verstehen also aims to systematically understand the behavior and actions of other people. This then led Weber to examine the contrasts between social action and social behavior, where it is critical to systematically understand how individuals subjectively relate to one another through social action (Kim, 2017; Ritzer, 2009). In fact, in the first chapter of his book, *Economy and Society*, Weber concludes that "only individuals can be treated as agents in a course of subjectively understandable action" (Ritzer, 2009). Weber concluded that social phenomena can be accepted only to the extent that they are captured by models of the behavior of purposeful individuals, which Weber referred to as **ideal types** (Allan, 2005). These principles lead to collaborative learning and the fundamentals of systems thinking. In anthropology, *verstehen* is a systematic interpretive process where an external observer from a different culture attempts to relate to and understand the locals within a new culture.

Weber's significant contribution to management theory is the development of the **bureaucratic organization model**. This model analyzes and describes the hierarchical power structures within organizations. The fundamental elements of this model include a hierarchical design with a transparent chain of command, rules, and regulations for work processes, a specialization of labor based on expertise, and impersonal decision-making rooted in rationality. This approach is designed to develop an efficient managerial system for handling multiple departments or divisions with a large number of employees.

Weber also designed essential social stratification ideas within organizations. These specific ideas are geared toward equity and inclusion. In fact, they specifically examine dominance or superiority achieved through informal and personal factors, such as wealth or connections, rather than actual qualifications or achievements. Further, he concluded that informal networks (personal connections and favoritism) are minimized if an organization becomes more effective in its operations by focusing on rational decision-making based on results.

After developing his principles of effective bureaucracy, Weber pointed out that modern organizations are dominantly based on rational-legal authority, which can often be very narrowly focused and impede effective communication.

Mary Parker Follett (1868–1933) was an American social worker, management consultant, philosopher, and pioneer in the fields of organizational theory and organizational behavior. She is often referred to as the "Mother of Modern Management." Analogous to Fayol, she also focused on people instead of machines or production processes. She advocated that people are the most valuable resource in any business. She was one of the first theorists to actively examine the role people played in effective management. Furthermore, her aims were to promote an amiable working environment as a critical aspect of the industrial sector (Tonn, 2003).

Follett developed and enhanced the holistic nature of community and the advanced practice of **reciprocal relationships**. Analogous to Max Weber's work in the principles of **Verstehen** and in his book on *Economy and Society*, this principle focuses on collaborative learning by understanding the dynamic aspects of an individual in relationship to others. She also advocated **integration** as inclusion, non-coercive power-sharing based on the use of her concept of "power with" rather than "power over" (Follett, 1940). Follett significantly contributed to diversity, inclusion, and thinking outside the comfort zone to determine integrated solutions rather than simply compromising.

George Elton Mayo (1880–1849) was an Australian psychologist, industrial researcher, and an organizational theorist. As an industrially oriented interdisciplinary researcher, he contributed significantly to the fields of business management, industrial sociology, philosophy, and social psychology. In Philadelphia, Mayo designed and enhanced a method to reduce the very high rate of turnover in a textile plant while conducting his field research there. As a consequence, Mayo's applied industrial field research had a substantial influence and contribution to industrial and organizational psychology (Trahair, 1984). Furthermore, Richard Trahair concludes that "Elton Mayo developed the scientific study of what today is known as the organizational behavior when he gave close attention to the human, social, and political problems of industrial civilization" (Trahair, 1984).

Elton Mayo's industrial field research laid the foundation for the human relations movement. In fact, he concluded that there exists an informal organizational structure within the assigned formal organization of an industrial workplace (Cullen, 1992). First, he detected and acknowledged "the inadequacies of existing scientific management approaches" in industrial organizations and indicated the essence of amiable and trustworthy relationships among staff for such organizations (Miner, 2006). In particular, he accurately described these group relations in his book *The Human Problems of an Industrialized Civilization* in 1933, which was based partly on his Hawthorne research (Mayo, 1933). In the **Hawthorne Effect** research, Mayo and his colleagues also concluded that the workers' awareness of being observed contributed to increased productivity.

Multiple observations are an important aspect of the learning process and relate to synthesis and inductive reasoning. Synthesis is an essential scientific tool that trains us to notice repeated patterns of certain characteristics prior to making any generalizations. More details on synthesis and inductive reasoning are discussed in Section 2.2.

1.2.2 *Leadership*

Leadership is defined as providing influential guidance to followers. Leadership presents the ability to impact and navigate individuals, teams, or organizations to accomplish a common and ethical task (Chin, 2015). Leadership blends individualized learning and collaborative learning. Leadership can be interpreted as an influential power relationship in which the power of one party, the "leader," promotes movement/change among "followers" (Northouse, 2018). The following characteristics present the essence of leadership:

> **Intelligence** originates from the Latin verb *intelligere*, which means to comprehend or perceive. Intelligence directs and connects to abstraction, logic, understanding, self-awareness, learning, emotional knowledge, reasoning, planning, creativity, critical thinking, and problem solving. Furthermore, it is the ability to perceive or infer information. To retain information, knowledge should be applied toward adaptive behaviors within a specific environment or context (Colom, 2010).
>
> In social sciences, **values** indicate the degree of importance. Personal values outline the spectrum of internal references for what is good, beneficial, important, useful, beautiful, desirable, and constructive. Values are one of the factors that influence decision-making and gravitate toward certain behaviors. Values also focus on determining a specific lifestyle, which actions are best to perform, and the significance of actions (Roth, 2013).

The diagram in Figure 1.7 outlines the categories of leadership.

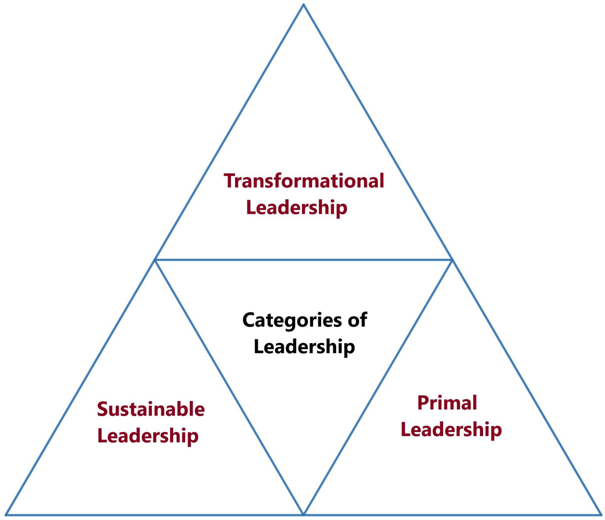


Figure 1.7. The categories of leadership.

More leadership traits are discussed in Sections 6.1–6.3.

1.3 Complexity

Complexity is interpreted as multiple interactions between components that result in a higher order of emergence that is greater than the sum of its parts (Heylighen, 1999). Complexity often leads to randomness, nonlinearity, and chaos. Complexity can arise when strong and noticeable contrasts emerge between interrelations among certain components of a system. In addition, one of the primary sources of complexity is the accumulation of consequences over time, which addresses short- and long-term memory.

Warren Weaver (1894–1978) was a mathematician and one of the pioneers of **machine translation**. Weaver studied **disorganized complexity** and **organized complexity** as two primary categories of complexity (Piore, 1979). First, he classified **disorganized complexity** as complexity that deals with probability theory and statistical mechanics. On the other hand, **organized complexity** confronts "dealing simultaneously with a sizable number of factors which are interrelated into an organic whole" (Weaver, 1948). The related diagram in Figure 1.8 presents the sources of complexity.

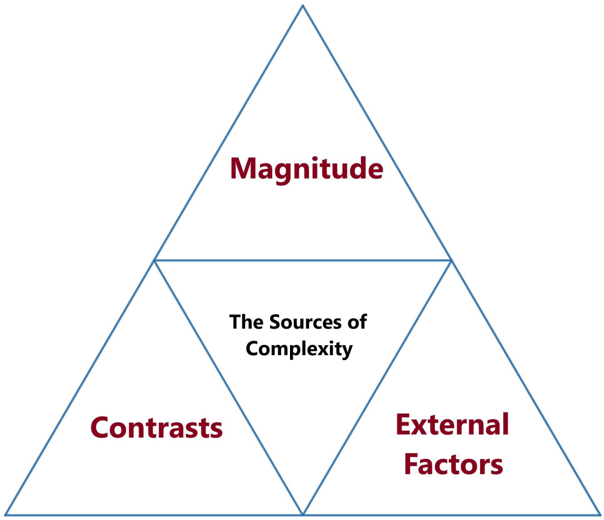


Figure 1.8. Sources of complexity.

The **magnitude** of a system or numerous components in a system leads to complexity. A large number of components increases the number of interactions and multiple interactions. This creates a challenge to understand how components interact with each other and to stay abreast. Systems with numerous components not only encounter complexity but also come across challenges with communications, resources, and sustainability.

Complexity can arise due to the **contrasts** that may exist among the components of a system. The stronger the contrasts, the harder it becomes to connect and interrelate the components. For instance, cross-disciplinary studies within a university and cross-departmental communication in an organization render such contrasts and complexity.

External factors also contribute to the complexity of a system as they increase the contrasts between the components and hence between the connections and the interrelations. For instance, cultural and international influences that occur due to globalization can be considered external factors.

The sources of complexity presented in Figure 1.8 also depend on individual perception and the extended knowledge of our perception of reality. This emphasizes the slow thinking path, overconfidence, and bias. In their paper, "Judgment under Uncertainty: Heuristics and Biases," Amos Tversky and Daniel Kahneman postulated that when people attempt to estimate or predict, they choose a certain base or starting point and gradually acclimate (Tversky and Kahneman, 1974).

Complexity also welcomes you to a diverse working environment and opens doors and windows of new horizons to expanding experiences, intuitions, and comfort zones. These include new collaborations, orientations, critical thinking skills, and two-directional exchange of ideas.

1.4 Diversity, Equity, and Inclusion

Diversity can be defined as a range of human differences which give rise to similarities and contrasts. The goals of diversity are to welcome and recognize various differences, balance the differences, stimulate individualized and collaborative learning, and establish effective, amiable, and trustworthy two-directional communication and exchange of ideas. Acknowledging and balancing such differences develops and enhances our cognitive and comparison skills.

Implementing diversity in the working environment leads to understanding the essential traits of tolerance, flexibility, equity, and inclusion. As mentioned in Section 1.1.6, understanding and applying Ashby's First Law of Cybernetics, or the law of requisite variety, the fundamentals of the synergy effect, and diversity are essential for survival.

The diagram in Figure 1.9 outlines the scheme of the primary range of diversities.

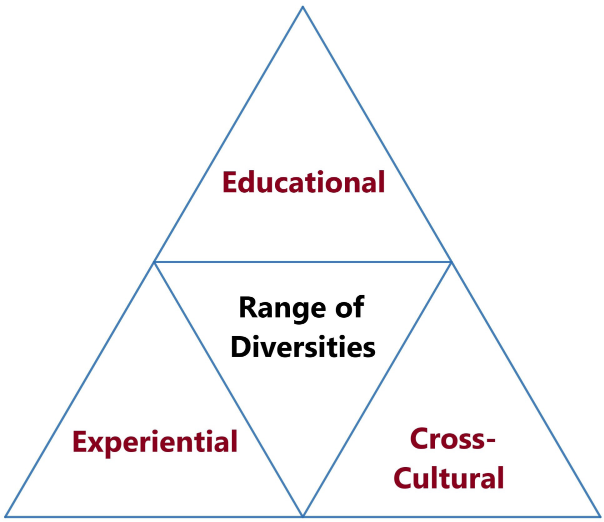


Figure 1.9. Range of diversities.

Sections 1.4.1 and 1.4.2 elaborate on the specific details that focus on the range of diversities described in Figure 1.9.

1.4.1 *Educational and experiential diversity*

Educational diversity naturally emerges among people due to differences in ages and generations, preparation levels, specific teaching and learning environments, teaching and learning styles, cognitive skills, and geographical regions. Educational diversity can also naturally arise due to similarities and contrasts in individualized learning paths and orientations and in individuals' pace of learning.

In addition, educational diversity emanates during education reforms that reveal new resources, technologies, courses, programs of study, and objectives. Cross-disciplinary studies include financial forecasting, physical anthropology, mathematical physics, mathematical biology, industrial engineering, and bio-engineering.

Effective implementation of educational diversity can lead to the exchange of ideas, the detection of mistakes and missing fragments, guided feedback, asking the right questions, new orientations and collaborations, and discovering new frontiers.

Experiential diversity is naturally encountered due to similarities and contrasts in experiences, intuitions, comfort zones, working environments, professions, and problem-solving skills. Experiential diversity also appears due to different available resources, technologies, priorities, and expected goals aimed at accomplishing them. These lead to focus on different details, asking different questions, solving different problems, and different interpretations of **Kolb's experiential learning cycle**. The cognate diagram in Figure 1.10 presents the four primary constituent of Kolb's experiential learning cycle.

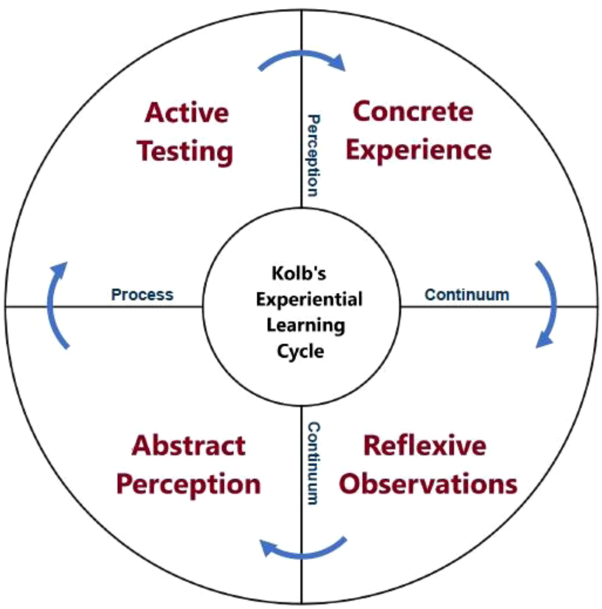


Figure 1.10. Kolb's experiential learning cycle.

Note that in Figure 1.10, the horizontal axis is the **processing continuum** (how we approach a task), while the vertical axis is the **perception continuum** (our emotional response, or how we think or feel).

Kolb's Experiential Learning Cycle is a four-step learning process which includes concrete learning, reflective observation, abstract conceptualization, and active experimentation. Effective learning outcomes are achieved by progressing through each stage. Note that an individual logical sequence of the learning cycle can be initiated at any given constituent in Figure 1.10, which outlines the following characteristics of each constituent:

1. **Concrete experience** is the first step of the cycle, which focuses on the daily personal interactions with others. In concrete situations, instead of applying a systematic approach to certain situations and problems, the learner depends more on feelings, flexibility and open-mindedness, and acclimation to change. The concrete experience stage enhances the learner's comfort zone and intuitions.
2. **Reflective observation** is the second phase of the cycle, which navigates learners to individually interpret a specific circumstance and welcomes them to pave their individualized learning path based on their feelings and thoughts. Reflective observations depend on objectivity, patience, and careful judgment prior to taking any action.
3. **Abstract perception**, or **abstract conceptualization**, is the third stage of the cycle that accurately assesses a certain situation or problem. This segment of the cycle directs learners to apply ideas, logical approaches, and developed concepts rather than relying on interpersonal feelings. In addition, during this segment of the cycle, learners depend on the systematic planning and formulation of ideas and theories to solve practical problems.
4. **Active testing**, or **active experimentation**, is the fourth and last experimentation stage of the cycle. In addition to observing others, the learners experience hands-on practice. The active

experimentation stage of the cycle reinforces the quote, "You do not learn by only observing others."

Observe that Kolb's experiential learning cycle displayed in Figure 1.10 presents a cyclical and iterative systematic learning process. During each iteration, progress is systematically monitored by emphasizing mistakes and missing fragments and with proper guidance. Active testing or reflections is the final and summative assessment phase of the cycle, which outlines the progress and provides guided feedback prior to repeating the cycle in the next iteration.

Kolb's Experiential Learning Cycle also presents a systematic scheme for developing individualized learning and self-assessment. This systematic scheme develops vital rudiments that lead to designing a stimulating teaching and learning environment and achieving the expected learning outcomes, especially in the online teaching and learning environment. This systematic and iterative approach also focuses on repetitive–style learning and presents applied, hands-on teaching and learning. Repetitive-style practice problems involve repetitions of identical or similar contents and emphasize the fundamentals of the quote "practice makes perfect."

Experiential diversity often occurs as cross-departmental and cross-disciplinary communication in an organization. These interactions can frequently involve people with various experiences, intuitions, problem-solving skills, and assigned tasks to perform. Effective implementation of experiential diversity can lead to detecting mistakes and missing fragments, asking the right questions, new orientations and collaborations, and a more efficient exchange of ideas and outcomes.

1.4.2 *Cross-cultural diversity*

Cross-cultural diversity is an essential international aspect of diversity due to perpetual international influences and the expansion of globalization, which introduce and encourage equity and inclusion. In fact, cross-cultural diversity indicates the similarities and contrasts in educational systems, economic systems, political systems, cultures, religions, races, genders, ethics, and value orientations. It aims to design amiable teaching, learning, and working environments by retaining the balance between leading and following, which also focuses on individualized vs. collaborative learning.

Moreover, cross-cultural diversity welcomes and expands international horizons by stimulating and paving a new path that leads to a collaborative, two-directional exchange of ideas and practices. What successful ideas and practices can you share with your foreign colleagues? What successful ideas can you adapt and transform from your foreign colleagues?

1.5 Creativity and Innovations

Creativity first originated from the Latin word "creare" (which means "to make"). **Creativity** is defined as the imagination of original and unique ideas. Creativity is also defined as the tendency to generate and recognize ideas, alternatives, or possibilities that may become beneficial in solving problems. Creativity requires thinking and imagination beyond the boundaries of our comfort zone. This often leads to taking and managing risks.

Creative learning is about acquiring knowledge and developing skills using creative techniques, and it requires critical thinking and imagination to create new ideas that needs one to be independent, flexible, and willing to take risks. Creative learning leads to imagination, divergent thinking, and designing an individualized learning path.

Creative cognition can be viewed as a set of mental processes that support the generation of novel and innovative ideas. It may also involve goal-directed, self-generated thought processes, particularly when cognition must be constrained to meet specific task demands (Beaty *et al.*, 2016). The creative cognition approach begins with a new look at an ancient subject and dreams. It then takes up intuition and insight from a contemporary cognitive perspective, considering the importance of using prior knowledge in the incremental view of creative problem-solving, which is contrasted with the importance of various forms of fixation and sudden insight.

Why be creative? Why is creativity inevitable in certain circumstances? The pyramid-shaped diagram in Figure 1.11 presents the three primary stimuli of creativity.

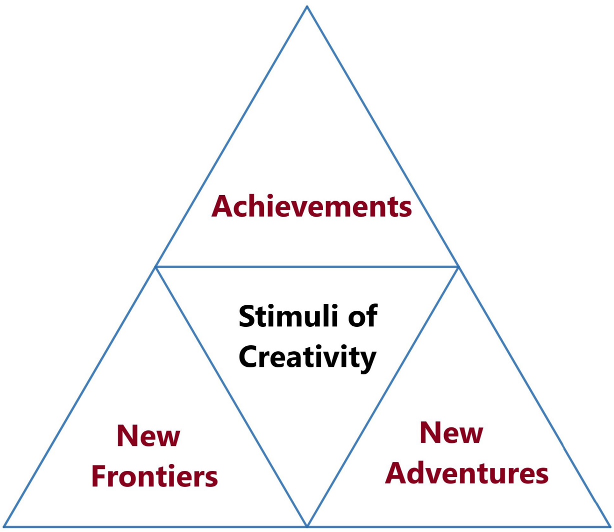


Figure 1.11. The three stimuli of creativity.

Innovation is defined as an introduction to something new. We can also define innovation as the tendency to generate new ideas and alternatives while solving specific problems. Analogous to creativity, innovation often requires thinking beyond the boundaries of your comfort zone. Innovation also expands learning horizons and promotes new ideas and practices. An innovation welcomes open–ended thinking and leadership. A successful innovation should be flexible to questions, feedback, and future improvements. Innovation has been an essential problem-solving tool for making improvements and leading to further progress during the last 200 years (Radin and Riashchenko, 2017; Orlova and Radin, 2018).

1.6 End of Chapter Summary

Understanding and applying the characteristics of systems thinking and complexity, combined with effective management and leadership practices, leads to diversity and opens new windows and doors to cross-disciplinary and cross-cultural comparisons and the exchange of creative and innovative ideas and practices. In addition, systems thinking, complexity, and effective leadership and management, together with diversity, develop and enhance our comparison, cognitive, and critical thinking skills, expand our experiences and comfort zones, and enhance our leadership skills that navigate to further improvements and more influential outcomes.

1.7 Further Thoughts

1. In Section 1.2, we discussed the fundamentals of management and leadership. What is the difference between management and leadership?
2. In Section 1.1, we discussed several aspects of systems thinking. Can systems thinking be applied to diversity, equity, and inclusion?
3. In Section 1.1.5, we discussed the fundamentals of systems thinking. In particular, we discussed analysis and synthesis. In which particular order do we start?
4. In Section 1.1.7, we discussed the applications of systems thinking. Can systems thinking be applied in online teaching, learning, and working environments?
5. In Section 1.4, we discussed the educational, experiential, and cross-cultural diversities. Discuss the four possible combinations of these diversities.
6. In Section 1.5, we discussed creativity and innovations. What is the difference between creativity and innovation?
7. In Section 1.3, we discussed the principles of complexity. Can complexity be viewed as a negative trend? If so, explain why and how.

Chapter 2

Fundamentals of Systems Thinking

Systems thinking is a beneficial tool used to systematically approach and understand complex structures, organizations, and the complex world. This is implemented by examining the entire system as a whole and its relationships rather than only studying the individual components. The following quotes outline the fundamental traits of systems thinking:

> "Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing 'patterns of change' rather than 'static snapshots'." — Peter Senge.
>
> "A system is never the sum of its' parts. It is the product of their interaction." — Russell Ackoff.
>
> "Many of the problems the world faces today are the eventual result of short-term measures taken last century." — Jay Wright Forrester.
>
> "Synthesis is about understanding the whole and the parts at the same time, along with the relationships and the connections that make up the dynamics of the whole." — Leyla Acaroglu.

The following five sections outline and reveal the primary fundamentals of systems thinking, which include the Forrester Effect, analysis and synthesis, components and connections, further applications of systems thinking, and rules of systems. Each fundamental will present its own unique characteristics and benefits that contribute to the fundamentals of systems thinking.

2.1 The Forrester Effect

Jay Wright Forrester (1918–2016) was an American computer engineer and systems scientist. He was the founder of the Systems Dynamic Group at the Massachusetts Institute of Technology (MIT) Sloan School of Management. Jay Forrester proposed an effect, later named the **Forrester Effect**, which describes the fluctuations in supply chains. The Forrester Effect, also known as the **Bullwhip Effect**, examines the supply chain phenomenon where supply exceeds demand. This circumstance occurs when orders to suppliers exceed the variability of sales to buyers. This then results in amplified demand variability upstream and hence leads to escalating swings in inventory in response to shifts in consumer demand as one moves further up the supply chain (Forrester, 1961).

The Forrester Effect is a phenomenon that occurs when a lack of visibility and transparency emerges in the supply chain, which then leads to a distortion of demand information as it moves upstream. This effect can cause a significant impact on various stakeholders in the supply chain, including customers, dealers, manufacturers, and suppliers.

At the **customer level**, the Forrester Effect can result in delayed order fulfillment or even stockouts as the distorted demand information is not delivered to the manufacturer in a timely manner. This can lead to dissatisfied customers, who may look to alternative and competitive suppliers in the future.

At the **dealer level**, the Forrester Effect can result in inflated or deflated demand signals, which can cause a mismatch between inventory levels and customer demands. This can result in higher inventory holding costs or lost sales opportunities, respectively.

At the **manufacturer level**, the Forrester Effect can cause fluctuations in production levels due to the distorted demand information. This can result in higher production costs, increased lead times, excessive inventory investment, lost revenues, misguided capacity plans, ineffective transportation, missed production schedules, poor customer service, and decreased customer satisfaction.

The diagram in Figure 2.1 presents a graphical example of distorted demand information and variability.

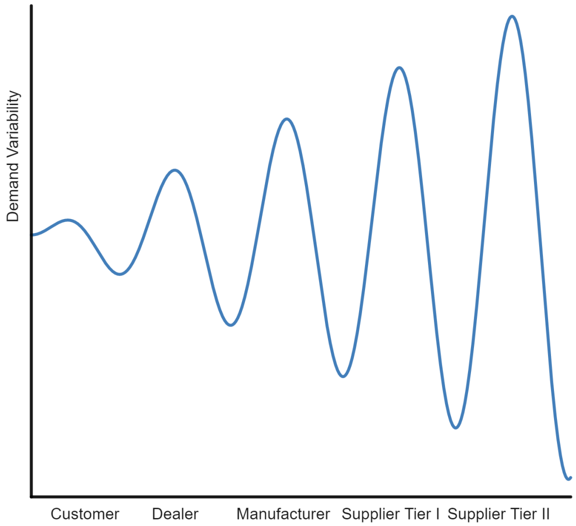


Figure 2.1. Distorted demand information & variability.

In Figure 2.1, first note that the Forrester Effect causes upstream disruptions in the supply chain at the Supplier Tier 1 level. Second, observe that at the Supplier Tier 2 level, the Forrester Effect causes the distorted demand signal from Tier 1 suppliers. As a consequence, this leads to a mismatch between the production and delivery schedules. Furthermore, this can result in higher inventory holding costs, stockouts, and longer lead times.

Generally, the Forrester Effect highlights the importance of transparency and communication in the supply chain. By improving visibility and sharing demand information in a timely and accurate manner, the negative impact of the Forrester Effect can be mitigated, which then leads to improvements in supply chain performance and customer satisfaction.

The **Forrester Effect** also originated from system dynamics. It is a modeling approach that uses feedback loops to simulate complex systems over time. This model helps decision-makers better understand how different components of an organization or system interact and allows them to make more informed decisions. The Forrester Effect states that the performance of any system can be improved through time compression and lead-time reduction.

2.1.1 *The Forrester effect and systems dynamics*

Jay Forrester is also known as the founder of **system dynamics**, which focuses on the simulation of interactions between the components in dynamic systems. The system dynamics approach is a method used to study and decipher how a system changes over time. The elements and variables that constitute a system that change with time are expressed as the system's behavior. The aim is to study and decipher the basic behavior system of the variables, discover the factors that cause this mode of behavior, and improve the system behavior. Therefore, it could be debated that system dynamics is a method to explain how systems change with time. In dynamic systems, the simultaneous influence of variables occurs. This technique is often applied in research and consulting in organizations and social systems.

System dynamics is a computer-aided approach for analyzing and solving complex problems that directs its focus on policy analysis and design. Forrester developed this field of study at MIT, which was initially called **industrial dynamics**. This approach uses a perspective based on information feedback and delays to accurately trace the dynamic behavior of complex physical, biological, and social systems. In fact, it treats the interactions between the flows of information, money, orders, materials, personnel, and capital equipment in a company, an industry, or a national economy. System dynamics is used to model and understand management problems. It considers the flow rates and accumulations linked by information feedback loops involving delays and nonlinear relationships.

System dynamics has numerous applications in corporate planning and policy design, economic behavior, public management and policy, biological and medical modeling, energy and the environment, theory development in the natural and social sciences, dynamic decision-making, complex nonlinear dynamics, and software engineering.

Jay Forrester defines industrial dynamics as the "study of the information-feedback characteristics of industrial activity to show how organizational structure, amplification (in policies), and time delays (in decision and actions) interact to influence the success of the enterprise. It treats the interactions between the flows of information, money, orders, materials, personnel, and capital equipment in a company, an industry, or a national economy."

John Sterman is the Jay W. Forrester Professor of Management, the current director of the MIT System Dynamics Group at MIT's Sloan School of Management, and a co-faculty at the New England Complex Systems Institute. He is widely considered as the current leader of the system dynamics school of thought. He defines **systems thinking** as "a mindset and a body of knowledge that examines the relationships between things, rather than just the things themselves" (Sterman, 2002).

John Sterman's definition of systems thinking highlights the importance of considering the relationships between the concepts in order to understand complex systems. This approach goes beyond examining just individual components or elements in isolation and instead examines how they interact and influence each other. By studying these relationships and interconnections, system thinkers can gain a deeper understanding of the behavior of a system as a whole and the potential impacts of changes within it.

In his book, *Business Dynamics: Systems Thinking and Modeling for a Complex World*, Sterman applies this mindset to the field of business and management by showing how systems thinking can help organizations better understand and navigate complex, interconnected business challenges. However, systems thinking can be applied to a wide range of fields and problem domains, such as public policy, healthcare, and environmental sustainability.

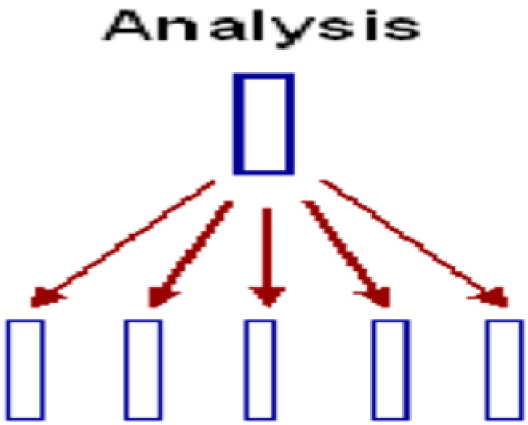
2.1.2 *The Forrester effect and applications*

Examples of applications of the Forrester Effect include reducing lead times to improve demand forecasting, quicker defect detection, and faster times to market. It can also be used for supply chain benchmarking by using a performance metric. In addition, it provides insights into how different components of the supply chain interact, which helps in better decision-making regarding policy development and international integration processes. The Forrester Effect should help manage disruption and resilience, as it helps to recover quickly after disruptions.

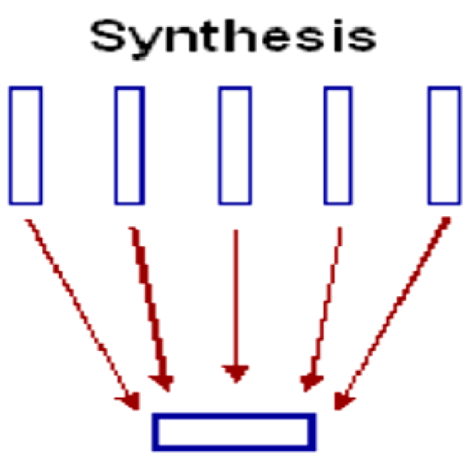
The Forrester Effect is an important application for supply chain management as it provides a framework to improve system performance through time compression and lead-time reduction. Reducing delays in the system can help reduce costs associated with inventory swings and production variations due to advertising policies or information technology use. It also helps increase customer quality service level and total cost by providing insights into how different supply chain components interact with each other and affect overall efficiency.

2.2 Analysis and Synthesis

Analysis addresses deduction and is the process of decomposing a complex theme into smaller, simpler, and manageable components in order to gain a better scheme of their interaction with each other. Analysis highlights individualized learning and hence individually examines each component and compares it to other components within the entire system. Analysis can be a beneficial tool to identify patterns, trends, and relationships between different elements, as well as potential solutions for problems that may arise from these interactions (Meadows, 2008). Analyzing different components of a system presents opportunities to detect the sources of a problem and missing fragments and hence determine potential solutions or strategies for managing and monitoring your working environment more effectively (Sterman, 2000), as displayed in the sketch below.



On the other hand, **synthesis** is induction and is the process of combining components together to form an integrated whole (Jackson, 2016). Synthesis is also the process of assembling individual components to design an integrated system. In comparison to analyzing individual components separately, synthesis emphasizes the virtues of collaborative learning and delves into a more comprehensive understanding of a system (Jackson, 2016), as presented in the corresponding sketch.



Synthesis inspects how different elements within a system interact with each other, including any feedback loops that may be present. Synthesis also examines the relationships between the components. In addition, synthesis aims to understand why certain outcomes occur, the emergence of different outcomes due to sensitivity to changing circumstances, and hence to more accurately monitor our environment to achieve the desired results (Sterman, 2010).

Synthesis also acquires ideas and information from multiple sources, coalesces them together, and then transforms them into new ideas and innovations. Synthesis can be used as a problem-solving technique by coming up with solutions based on existing knowledge as well as generating creative approaches to more challenging problems (Meadows, 2008).

Synthesis is an important part of the learning process as it strongly focuses on **repetitions**. In fact, repetitions perform as a very crucial fragment during the learning process when studying music and learning to play a musical instrument, studying a foreign language, and during sports practices (Keller–Margulis, 2012; Yakovlev and Yakovleva, 2014). Psychologists sometimes observe thousands of repetitions of particular behavior(s) before coming to any conclusions. Furthermore, the department of transportation observes repetitions in traffic patterns numerous times before any decisions are made regarding any construction projects.

Repetition is also an essential resource in teaching and learning, as students begin to detect their mistakes after solving several repetitive types of problems. Furthermore, teachers begin to detect students' frequent mistakes after solving several repetitive types of problems, can emphasize the common mistakes to their students, and recognize the differences in the students' varying learning styles (Grasha and Yangarber-Hicks, 2000; Iyer *et al.*, 2001).

2.3 Components and Connections

Leyla Acaroglu identifies interconnectedness, synthesis, emergence, feedback loops, causality, and systems mapping as the six most important themes in systems thinking. The sketch in Figure 2.2 outlines various interconnections between components depending on a specific circumstance.

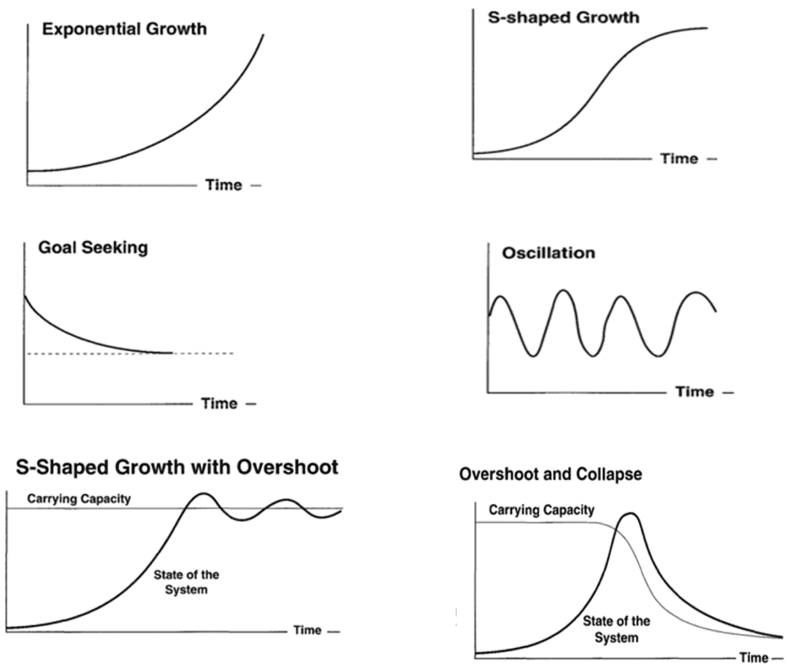


Figure 2.2. Examples of interrelated components.

Figure 2.2 is an example of **nonlinearity**, as the outcomes strongly depend on each specific circumstance and input. The following three sections elaborate on supplemental details that assume sensitivity to inputs. More details on the modes or patterns of behavior presented in Figure 2.2 are discussed in Sections 4.1–4.6.

2.3.1 *Dynamics of change*

The **dynamics of change** examines people's reactions or sensitivity during adaptation to changes, reforms, or revisions within their environment and adaptation to a new environment as well. The following are examples of frequent discomfort sources that can naturally emerge during the adaptation process:

1. First, discomfort can occur as some people may not understand the **potential benefits or consequences** as a result of changes, reforms, or revisions. It takes time for people to process and understand new reforms and revisions.
2. Discomfort can naturally arise as some people may not be ready for specific changes, reforms, or revisions due to their **educational background, preparation level, or experiences**. It takes time for people to adapt to the new environment and understand the revised or new system.
3. The feeling of discomfort may come about as each individual **adapts at his/her own rate**. Each person has his/her own individualized learning style and interprets each circumstance with a unique perspective and with specific goals and orientations.
4. Possible **compromises and sacrifices** as a consequence of changes, reforms, or revisions can certainly lead to discomfort. What do I compromise, and how will this affect me down the road?
5. Questions regarding **resources and sustainability** can result in discomfort as well. Do we have the resources to implement such revisions and reforms? Where do I obtain the necessary resources?

Furthermore, the dynamics of change is important to consider, as systems are dynamic and change quite frequently. Detecting the sources of change in a system is essential to accurately and precisely trace its behavior. The potential sources of change include positive feedback loops, nonlinear relationships, interdependence, time delays, and adaptation and learning.

Positive feedback loops in business can emerge when a change in one factor leads to an increase in another factor. This then leads to further increases in the first factor. For instance, a company's successful launch of a new product can lead to positive customer reviews and increased sales, which then leads to increased investment in marketing and further product development.

Nonlinear relationships can occur in a business when a marginal change in one factor leads to an unpredictable outcome. For example, when the relationship between price and demand is not always straightforward, a marginal change in the price of a product can lead to a significant change in demand for that product.

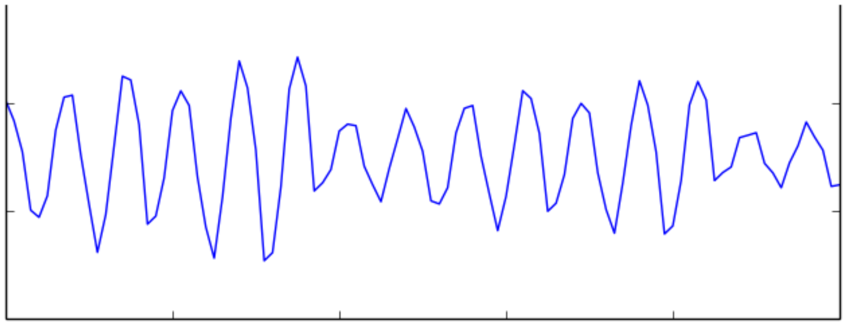
Interdependence in business can arise when different parts of a system are interconnected and influence each other. Changes in customer preferences can lead to changes in supply chain management, which can then lead to changes in production and distribution strategies.

Time delays are frequent phenomena that occur in businesses, as it takes time for the systems to adapt and feel the effects after the changes are implemented. It may take time to see changes in consumer behavior in sales data, and it takes time for businesses to adapt to technological changes.

Adaptation and learning are important to stay flexible, stay fresh, and keep up with competitors. Businesses may need to adapt to changing consumer preferences or new technologies, and individuals may need to learn new skills and knowledge to stay competitive in their industries.

2.3.2 *Nonlinearity*

A **nonlinear system** is one in which the output is not proportional to the input. The study of nonlinear systems raises curiosities as they can often reveal chaotic, unpredictable, or counterintuitive behavior. Sensitivity to initial input is frequently encountered in nonlinear systems, as presented in Figure 2.2. The consequent graph displays the chaotic behavior of a non-autonomous discrete neuron model (Pisarchik *et al.*, 2015).



Nonlinearity can often emerge in numerous situations, such as sensitivity to changing prices or cultural differences, funding for a start-up, the relationship between performance and rewards, the relationship between market size and competition, and labor market dynamics.

Sensitivity to changing prices in emerging markets is an example of nonlinearity. In fact, in some emerging markets, the price–demand relationship can appear highly nonlinear. A small increase in price may result in a significant decrease in demand due to the limited purchasing power of consumers.

Sensitivity to the impact of cultural differences is also an example of nonlinearity. In particular, cultural differences can lead to nonlinearities in business operations, such as the need for significant changes in product design, marketing strategies, and communication styles.

Funding for start-ups, especially during the early stages of a start-up, can be highly nonlinear. This also includes securing funding. In fact, even a small amount of funding can lead to significant growth opportunities, while a lack of funding can lead to stagnation or failure.

The **relationship between performance and rewards** in organizations can be highly nonlinear. In many instances, small differences in performance may not lead to significant differences in rewards, while large differences can lead to significant differences in pay and bonuses.

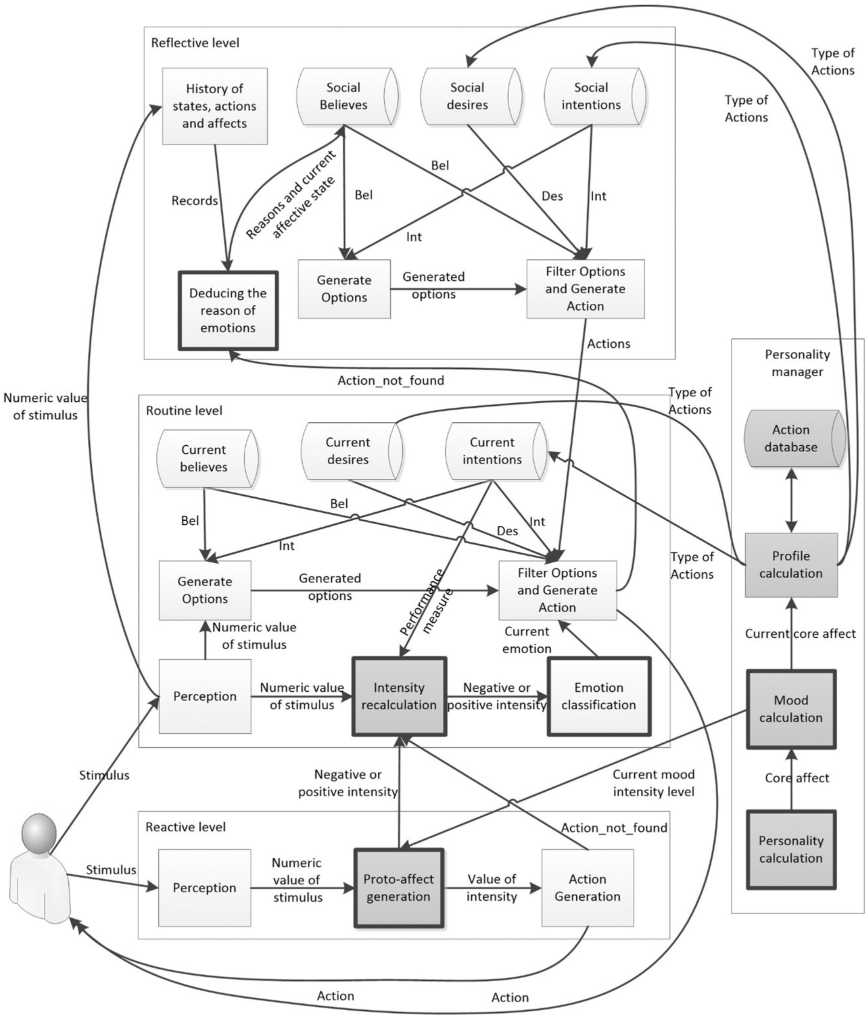
The **relationship between market size and competition** can be nonlinear in different geographical regions. A small market with few competitors may be highly profitable, while a large market with many competitors may be highly competitive and less profitable.

The **labor market dynamics** in different geographical regions can exhibit nonlinear dynamics due to differences in labor regulations, cultural norms, social status, and economic conditions and distributions. In some regions, a small increase in the minimum wage may lead to significant changes in employment levels, while in other regions, it may have little impact. This phenomenon is thoroughly studied in spatial effects and economic cycles (Kulikov *et al.*, 2022).

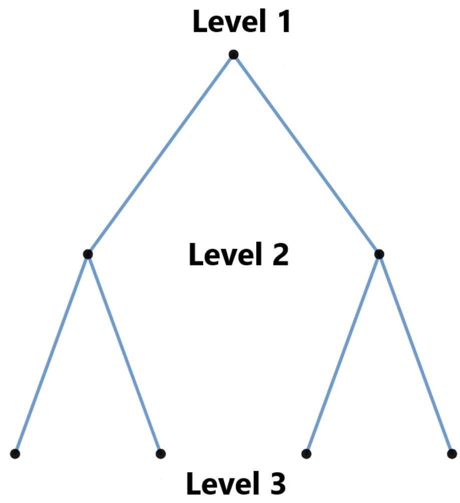
2.3.3 *Agent-based vs. hierarchical systems*

Distinguishing the contrasts between agent-based and hierarchical systems can help systems thinkers identify the most accurate approach for analyzing a particular system.

An **agent-based system or model** examines the actions and interactions of autonomous agents (individual and group entities) to accurately and precisely understand the behavior of a system and what factors regulate the outcomes. The method applies the fundamentals of game theory, complex systems, emergence, computational sociology, multi-agent systems, and evolutionary programming. Computer simulations often describe agent-based systems or models and are assembled as numerous agents specified at various scales (agent granularity), decision-making heuristics, and adaptive processes. The following diagram presents the agent-based modeling of human emotions (Lavendelis *et al.*, 2016).



On the other hand, a **hierarchical system** presents a scheme of people with different ranks or positions in administrative or managerial positions either in government, military, corporation, university, or some organization, as displayed in the following hierarchical tree diagram.



In a university administration, the provost position would be in level 1, the dean position would be in level 2, and the department head position would be in level 3.

Agent-based and hierarchical systems are two different means of arranging individuals or entities within a system. The main difference between the two systems is the level of autonomy and decision-making power given to individuals or groups within the system.

Agent-based model refers to individuals or groups within a system who have a high degree of autonomy and decision-making power. They are able to act independently and make decisions that can affect the overall behavior of the system. In a system with a large number of agents, there is a lack of hierarchy or chain of command.

On the other hand, **hierarchical systems** are structured with a clear chain of command and well-defined roles and responsibilities. In a hierarchical system, decision-making power is concentrated at the top, and individuals or groups lower in the hierarchy are expected to follow the direction of those above them. Hierarchies are often used in organizations or institutions where there exists a transparent decision-making system.

One fundamental and notable difference between agent-based and hierarchical systems is the level of complexity they can handle.

Hierarchical systems can be more efficient in managing large and complex systems, as they provide clear structures and roles that can help avoid confusion and inefficiencies. However, hierarchical systems can be inflexible and slow to adapt to changing circumstances, as decisions often need to be made at the top of the hierarchy.

On the contrary, systems with a large number of agents can be more adaptable to changing circumstances, as individuals are able to respond to changes and make decisions based on their local knowledge and expertise. However, systems with a high number of agents become more complex with a very limited chain of command or accountability and hence can become more challenging to manage.

Overall, the choice between agent-based and hierarchical systems depends on the specific needs of the system and the environment. We can conclude that the hierarchical system has slower roles in comparison to agent-based systems. Agent-based systems present more dynamic communication among the components and orient toward a more flexible, creative, and diverse working environment. More details on the contrasts and transitions between the hierarchical and agent-based systems are discussed in Chapter 5. More thorough details on roles are presented in Chapter 7.

2.4 Further Applications of Systems Thinking

In Section 1.1.7, Figure 1.5 outlines the scheme of systems thinking applications. The subsequent three sections explore the supplemental applications of systems thinking in industry, government services, and education.

2.4.1 *Applications in industry*

Siemens AG is a German multinational conglomerate corporation and the largest industrial manufacturing company in Europe. Its headquarters are in Munich, and it has several international branch offices. Siemens has been applying the fundamentals of systems thinking to various aspects of its operations for many years. Some of the key applications of systems thinking at Siemens are innovation and product development approaches. Siemens uses a systems thinking approach to identify market trends and customer needs and to develop products and solutions that meet these needs.

The sustainability approach is another application of systems thinking at Siemens. The company has been using a systems thinking approach to integrate sustainability into all aspects of its operations, from product design to manufacturing to end-of-life management. This approach helps Siemens reduce its environmental impact, conserve resources, and promote sustainable development.

Siemens has also been applying systems thinking to risk management. The company uses a systems thinking approach to identify and assess potential risks throughout its operations and to develop and implement strategies to mitigate those risks. This approach helps Siemens ensure the stability and resilience of its operations and manage risks effectively.

2.4.2 *Applications in government services*

The Royal Mail Group is a British multinational postal service and courier company established in 1516 as a government department. The Royal Mail Group has been applying systems thinking to various aspects of its operations, such as customer service, supply chain management, sustainable operations, and process improvement.

The Royal Mail Group has been using a systems thinking approach to improve its **customer service**. The company has been working to identify the root causes of customer complaints and develop solutions that address these specific problems. This approach has helped the company improve customer satisfaction, reduce complaints, and enhance the overall customer experience.

The Royal Mail Group has been using a systems thinking approach to optimize its **supply chain management**. The company has been working to identify bottlenecks and inefficiencies in its supply chain and to develop solutions that improve the flow of goods and information. This approach has helped the company reduce costs, improve efficiency, and enhance customer satisfaction.

The Royal Mail Group has been using a systems thinking approach to integrate sustainability into all aspects of its **sustainable operations**. The company has a strong aim to reduce its environmental impact, conserve resources, and promote sustainable development. This approach has helped the company reduce its carbon footprint, conserve energy and water, and enhance its reputation as a responsible and sustainable business.

The Royal Mail Group has been using a systems thinking approach to continuously improve its operations and for **process improvement**. The company focuses on identifying areas for improvement and implementing changes that enhance efficiency, reduce waste, and improve the overall performance of its operations. This approach has helped the company stay ahead of its competition, improve its bottom line, and enhance customer satisfaction.

2.4.3 *Applications in education*

In the educational system, the fundamentals of systems thinking can be a beneficial tool in education at the **institutional level**, in particular, to improve the performance of students, teachers, and administrators. For example, within a school or university, educators can use the fundamentals of systems thinking to study the interactions between different departments and stakeholders, identify the problematic areas that require improvement, and develop strategies to enhance collaboration and communication. This can be particularly useful for large institutions with complex structures and multiple stakeholders.

The characteristics of systems thinking can also be applied in education at the **district level** by analyzing the interactions between different schools and stakeholders within a specific district. Educators can apply the features of systems thinking to identify areas where resources could be better allocated across schools or to develop strategies to improve communication and collaboration between schools within a district.

The attributes of systems thinking can be applied at the **state or national level** within the department of education to revise educational policies, programs of study, and outcomes. Educators and policymakers can use the traits of systems thinking to analyze the interactions between different policy areas, such as curriculum, assessment, and teacher training, and develop strategies to ensure that policies are integrated and aligned. This can be particularly vital in complex educational systems with diverse multi-cultural populations.

For example, the **University of British Columbia** used the fundamentals of systems thinking to develop interdisciplinary programs that bridge different departments within the university. The Science One program combines biology, chemistry, and physics in a single course.

The Finnish National Agency for Education is responsible for developing educational policies and implementing reforms in Finland. They applied systems thinking to analyze the interactions between different policy areas, such as curriculum, assessment, and teacher training, and develop strategies to ensure that policies are integrated and aligned.

2.5 Rules of Systems

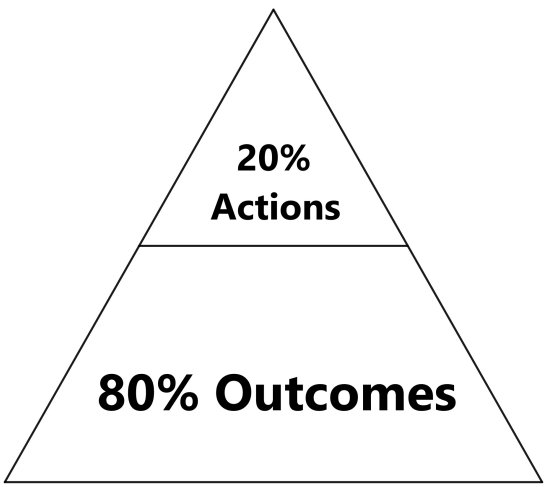
The **rules of systems** refer to the underlying principles that govern how a system operates. Establishing these rules is essential to understanding and predicting the system's behavior. The following two sections elaborate on the 80/20 principle and Ashby's law.

2.5.1 *The 80/20 principle*

The 80/20 principle states that 20% of the inputs to a system are responsible for 80% of the outputs. By understanding which inputs impact the system, systems thinkers can focus their efforts on prioritizing and addressing the most important criteria.

The 80/20 principle is a management strategy that states that employees should spend 80% of their time on core tasks and only 20% of their time on non-core activities. This approach encourages workers to focus more intently on the most important aspects of their job while allowing them some flexibility in how they use the remaining portion of their workday. This system aims to maximize efficiency by ensuring that all available resources are being used effectively and efficiently toward achieving organizational goals (Meadows, 2008).

The 80/20 principle is a concept that states that 80% of outcomes can be attributed to just 20% of the causes. This principle has been applied in many different fields, including economics and business management. It suggests that by focusing on the most important factors or activities (the top 20%), we can achieve better results than if we spread our efforts across all elements equally (the bottom 80%). By understanding this relationship between cause and effect, businesses are able to identify areas on which they should focus their resources for maximum efficiency and effectiveness (Sterman, 2000). The corresponding diagram presents a graphical representation of the 80/20 principle.



The 80/20 principle is a concept that states that 80% of an organization's results come from just 20% of its activities. This means that organizations should focus their efforts on those areas where they can have the most impact, rather than spreading themselves too thin and trying to do everything at once. The idea behind this principle is to identify which tasks are essential for achieving success and then prioritize them accordingly in order to maximize efficiency and productivity.

Last but not least, the 80/20 principle is an important principle in education. In particular, it states that 80% of the learning occurs outside the classroom. The 80/20 principle reemphasizes that "you do not learn only by observing others."

2.5.2 *Ashby's law*

The First Law of Cybernetics, also referred to as the Law of Requisite Variety or **Ashby's Law**, states that a system must be flexible and adaptable in order to function effectively. Ashby's Law is a critical fundamental concept of cybernetics which states that the complexity of an adaptive system must be greater than or equal to the environment it operates in. W. Ross Ashby developed this law. In fact, he argued that for any given problem, some level of complexity is necessary for its solution, which can only be achieved through adaptation over time. In fact, Ashby's Law claims that if a system does not have enough internal resources (complexity), it will eventually become overwhelmed by external changes and hence will unable to adapt quickly enough to survive (Meadows, 2008).

Ashby's Law is a fundamental cybernetics idea that claims that "a system cannot be controlled or made more complex without adding additional components." This law has been used to explain the behavior of many different types of systems that range from biological organisms to computer networks. The following quote describes Ashby's motives for developing this law: "If you want something to become more efficient or effective, then it must also become larger and/or contain additional elements — otherwise its complexity will remain limited" (Sterman, 2000).

Ashby's Law claims that for any system to remain viable, it must be highly flexible, adapt, and respond quickly enough to keep up with changes within its environment. Ashby argued that feedback loops are essential to systems in order to adjust their behavior accordingly when new challenges or opportunities are encountered. Therefore, it is important to design a flexible and adaptive environment that focuses on creative thinking outside the comfort zone and to effectively handle problems as they arise instead of relying on pre-existing solutions or processes which may no longer be applicable (Jackson, 2003).

The formalized version of Ashby's Law can be formulated by the following equation:

$$V_r \;\geq\; V_d - V_o, \tag{2.1}$$

where:

(i) V_r is the diversity of potential responses;
(ii) V_d is the complexity of problems (or the diversity of disturbance factors);
(iii) V_o is the diversity of results (actions).

Observe that Eq. (2.1) describes the relationship between the diversity of potential responses, the complexity of problems (or the diversity of disturbance factors), and the diversity of results (actions) tolerable by key variables.

2.6 End of Chapter Summary

Systems thinking will train and enhance your comparison, cognitive, and critical thinking skills. The essentials of systems thinking lead us to ask the following question: What are the relations, similarities, and contrasts between the components? The features of systems thinking direct you to notice specific details and observe occurrences numerous times prior to drawing conclusions and formulating theories and hypotheses. What specific systematic reoccurrences arise, and why? Do certain conditional phenomena emerge due to specific initial inputs? The principles of systems thinking will also lead you to understanding and applying the fundamentals of emotional intelligence.

2.7 Further Thoughts

1. In Sections 2.3 and 2.3.2, we discussed nonlinearity and components & connections. Does adding or removing a component relate to nonlinearity?

2. In Section 2.3.3, we discussed the hierarchical and agent-based systems. Can we conclude that the **hierarchical system** presents a **managerial-style system** and the **agent-based system** presents a **leadership-type system**?
3. In Section 2.4, we discussed a few applications of systems thinking in industry, government services, and education. How can the principles of systems thinking be applied in studying medicine, psychology, and meteorology? More specifically, how can they be applied to studying the Alpine formation?

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Chapter 3

Systems Thinking Tools

Systems thinking is an instrumental method to systematically understand complex structures, organizations, and the complex world. Analysis examines and applies the interrelationships between individual components. Synthesis assembles a system by uniting all the elements together. In Chapter 2, we discussed additional methods such as the dynamics of change and the rules of a system. Our aim is to develop supplemental systems thinking methods to solve a wider range of more complex and challenging problems. These include problem-solving methodologies and soft vs. hard tools. We also include the advantages and supplemental applications of these tools. Section 3.1 will explore various problem-solving methodologies.

3.1 Problem-Solving Methodologies

Systems thinking is a specific problem-solving methodology. William Edwards Deming's quotes outline the fundamentals of system-oriented business dynamics and problem-solving methodologies:

> "I should estimate that in my experience most troubles and most possibilities for improvement add up to the proportions something like this: 94% belongs to the system (responsibility of management) 6% special."
> "It is not enough to do your best. You must know what to do, and then do your best."

The systems dynamics methodology was first developed by Jay Forrester, John Sterman, and Donella Meadows. It is a powerful approach for understanding complex systems and developing effective solutions to complex problems. This methodology focuses on the use of feedback loops, stocks and flows, and causal relationships to model the behavior of a system over time.

In the context of problem-solving, systems dynamics methodology outlines the structure of the problem, identifies the key variables and their relationships, develops a dynamic model that captures the basic interactions in the system, and simulates the system to test different interventions.

Sections 3.1.1–3.1.3 present examples of the unique traits, tactics, and applications of various problem-solving methodologies. Section 3.1.1 commences with the unique features of the action research methodology.

3.1.1 *Action research*

Action research is a collaborative problem-solving technique. **Action research** is a systems thinking problem-solving technique that highlights collaborative attempts at accurately diagnosing a problem and determining the solution based on the diagnosis. The collaboration involves efforts between the researcher and a member of the organization and aims to solve specific organizational problems. In particular, action research involves stakeholders by gathering data from multiple sources, analyzing patterns and trends, and developing hypotheses about possible solutions based on those findings before finally implementing any changes recommended by the results.

Action research is applied when it addresses change and improvement (Coughlan and Coghlan, 2002). Action researchers focus not only on change and improvement but also on reflecting on what happened (Coghlan and Brannick, 2005). Furthermore, action research has been successfully implemented by managers who have engaged in their own organizations' action research projects with positive outcomes (Cagney, 2015). Action research can be individually examined as a positivist, interpretive, or critical approach.

A **positivist action research approach** is also referred to as "classical action research" and recognizes research as a social experiment. Action research is an accepted method for testing hypotheses.

An **interpretive action research approach**, also referred to as "contemporary action research," views a business as a social structure and specializes in identifying organizational factors.

A **critical action research approach** is a specific type of action research that applies the critical approach, aiming to revise and improve business processes.

Cyclical dynamics begins with an accurate diagnosis by identifying and defining a problem. Figure 3.1 illustrates the principles of the action research.

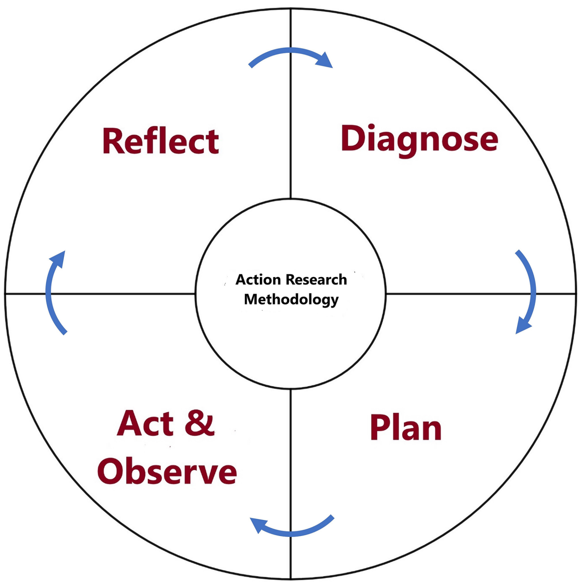

Figure 3.1. Principles of the action research methodology.

The cyclical nature, as shown in Figure 3.1, involves gathering data from multiple sources (including interviews and surveys), detecting patterns, and then formulating possible solutions based on those sources:

- **Diagnosing** involves detecting, identifying, and recognizing what the problems are and what further actions to plan and take.
- **Planning** is a consequence of the diagnosis that outlines the scope of the problem. Action planning also focuses on the first step or on a series of steps.
- **Observing and taking action** focuses on implementing the plan to solve the problem. It is often implemented together with intervention.
- **Evaluation**, or **reflection**, is the final stage of the cycle. It focuses on reflecting on or evaluating the effectiveness of the process and the solution. In addition, it also considers possible revisions, improvements, and alternatives.

3.1.2 *Theory of constraints*

The theory of constraints (TOC) was developed by Eliyahu M. Goldratt during the 1980s. In his book *Theory of Constraints*, Goldratt defines a constraint as "anything that limits a system from achieving higher performance vs. its goal." In particular, this implies that the constraints are the factors that prevent the system from achieving its desired performance.

The **TOC** is a management philosophy and tactic which focuses on identifying and managing constraints that limit an organization's ability to achieve its goals. Every system, such as a business, a manufacturing process, or a natural system, has constraints. These constraints include limited outcomes, production, and profit.

The TOC is also a system thinking technique that examines any manageable system that is oriented toward achieving expected outcomes and goals within limited constraints or resources. It focuses on maximizing outcomes and goals with limited or constrained resources. Figure 3.2 displays the five cycles of the TOC.

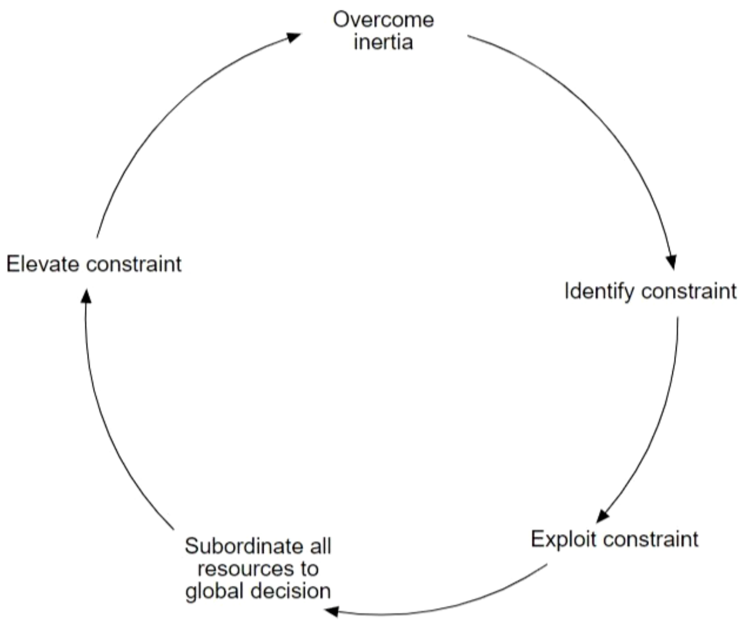

Figure 3.2. The five cycles of the theory of constraints.

1. The first essential step is to **identify the constraint**. This involves identifying and understanding the limiting factors that are impeding an organization from achieving its goals.
2. Once identified, **exploiting the constraint** is the next step of the cycle. In fact, this focuses on exploiting or maximizing the resources related to the particular bottleneck process in order to maximize the overall performance within the given limited resources.
3. After exploiting the constraint, it is important to **subordinate and synchronize** everything else to the constraint. This is a vital filtering process to prevent any potential interference with optimizing the performance at the constrained step/process.
4. If necessary, it is essential to **elevate** the constraints. In particular, if challenges arise during a single process or activity to meet the demand due to limited capacity, additional investments may be

required in order to elevate the limitation and hence increase the output further in order to increase the available resources, such as personnel and equipment.

5. The final step of the process is to **overcome the inertia** by repeating steps 1–4 until all the desired objectives are achieved. After the successful completion of each iteration of these four steps, the cycle repeats by re-identifying any new bottlenecks which have arisen from the previously implemented changes.

The constraints within a system present new opportunities for revisions and improvements. First, the performance can be improved and increased by identifying and removing the constraints. Therefore, it is important to identify and address the constraints in order to maximize the performance of the system. Second, it becomes a vital task to understand the limiting constraints and how to achieve the maximum expected outcomes within the limited constraints.

3.1.3 *Systems dynamics*

John Sterman developed and applied **systems dynamics** to model business and economic systems. In his book, *Business Dynamics*, he provides a comprehensive introduction to his methodology and its applications in business and presents the corresponding characteristics of his methodology:

1. The first step in **problem structuring** is to clarify the problem that concerns the decision-makers. This involves identifying the root cause of the problem and the variables that impact it. Decision-makers can develop effective strategies to address the problem by obtaining a solid basis for understanding the problem and its causes as well.
2. **Causal loop modeling** is the process of constructing a feedback loop model that reveals the relationships between the variables identified in the problem structuring phase. This model helps decision-makers better understand how the different variables interact with one another and how changes in one variable can affect the others. By visualizing these relationships,

decision-makers can identify the key leverage points in order to intervene in the system.

3. **Dynamic modeling** involves the creation of a mathematical model that captures the basic interactions in the system. This model is assembled based on rates and levels, which can then be transformed into a computer simulation using the custom-designed software. By simulating the system, decision-makers can obtain a better grasp on how the system operates over time and how different variables affect its behavior.
4. **Scenario planning and modeling** is the process of validating the dynamic model by comparing its behavior with real-world activity. Once a reliable correspondence has been achieved, experiments are conducted on the model to determine how alternative decisions can improve performance. Decision-makers can use these experiments to test different strategies and identify the most effective ones.
5. **Implementation** involves decision-makers' recommendations that aim to change and improve the situation. By using the insights gained from problem structuring, causal loop modeling, dynamic modeling, and scenario planning, decision-makers can develop and implement effective strategies to address the problem. By monitoring the system over time and making the necessary adjustments, decision-makers can ensure that their interventions are successful and sustainable.

3.2 Soft Tools vs. Hard Tools

Now, let's examine the contrasts between the soft tools and hard tools of systems thinking. **Soft tools** are qualitative and subjective approaches used in system science that focus on understanding and analyzing the social and cultural aspects of complex systems, such as organizational culture, power dynamics, and stakeholder perspectives. Soft tools are often used to explore complex systems that involve a high degree of human interaction and subjective judgment. Soft tools outline the overall general scheme of a specific system. For example, a soft tool such as dialogue mapping can be used to facilitate communication and collaboration between different stakeholders in a project. Soft tools are also beneficial tools for analyzing and managing the social and cultural factors that can affect a system's performance. Additional examples of **soft tools** include systems thinking, Meadows's sustainability model, hierarchical systems, the 80/20 principle, action research, and dialogue and deliberation.

In contrast, **hard tools** are quantitative and analytical approaches applied in system science. In particular, hard tools are applied in developing mathematical models, algorithms, and computer simulations to analyze and predict the behavior of complex systems. Hard tools are used to analyze and manage the technical aspects of a system. Hard tools such as simulation software can be used to model and test the behavior of a complex system. Hard tools are often used to optimize the performance of a system by identifying and addressing technical problems. Additional examples of hard tools include system dynamics, network analysis, data analytics, machine learning, and artificial intelligence. These are mathematics-oriented tools that aim to accurately describe the specific traits or components of a system.

The level of complexity is the first fundamental difference between soft and hard tools. Soft tools are generally better suited for systems that involve a high degree of uncertainty, ambiguity, and subjective judgment. They are also a better match for systems that involve a high degree of social interaction and collaboration. On the other hand, hard tools are a better fit for systems that involve a high degree of technical complexity and require thorough analysis and optimization.

Another essential difference between soft and hard tools is the level of skill and expertise required to use them effectively. Soft tools often require strong interpersonal skills and a deep understanding of human behavior and social dynamics. On the other hand, hard tools often require a high degree of technical expertise and specialized knowledge.

Sections 3.2.1 and 3.2.2 present causal loop, stock, and flow diagrams as supplemental examples of hard tools, and Section 3.2.3 presents the iceberg model as an additional example of soft tools.

3.2.1 *Causal loops*

Causal loop diagrams (CLDs) present the relationships between the system's components and demonstrate the dynamics of a certain phenomenon that helps students focus on the lecture theme. In addition, CLDs increase the students' cognitive skills by bridging different concepts together. A CLD consists of variables connected by arrows denoting the causal influences among the variables and consists of four basic elements:

1. Variables;
2. Links between variables;
3. Signs on the links, which show how the variables are interconnected;
4. A sign on the loop, which shows what type of behavior the system will produce.

In addition, a CLD consists of variables connected by arrows denoting the causal influences among the variables. The important feedback loops are also identified in the diagram. The causal links are emphasized by arrows and relate to the variables. Each causal link is assigned a polarity, either positive (+) or negative (−), to indicate how the dependent variables change (Sterman, 2000). CLDs model boundary charts, and subsystem diagrams show the boundary and architecture of the model but do not necessarily show how the variables are related.

CLDs are flexible and useful tools for presenting the feedback structure of systems in any domain. They are simply maps showing the causal links among the variables with arrows from a cause to an effect (Sterman, 2000). CLDs emphasize the feedback structure of a system. A causal diagram consists of variables connected by arrows denoting the causal influences among the variables. The important feedback loops are also identified in the diagram, where the variables are related by causal links emphasized by arrows. Figure 3.3 presents an example of a CLD that demonstrates the interactions among customers, retailers, wholesalers, and manufacturers.

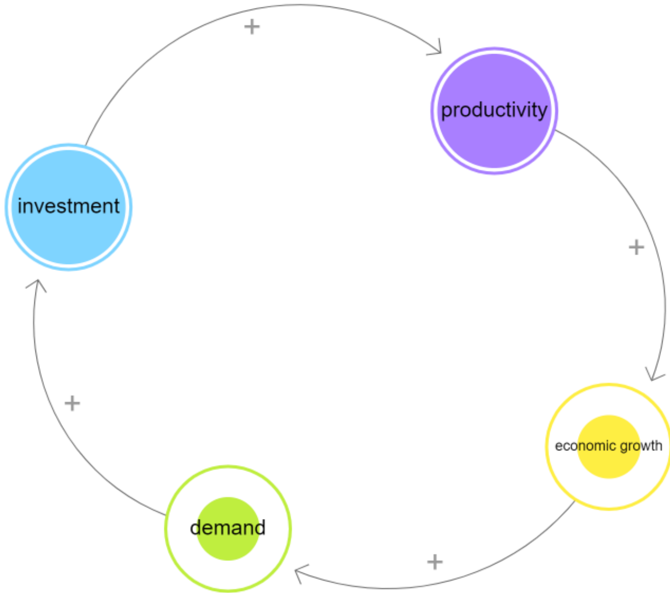

Figure 3.3. Causal loops: Four channels of distribution.

Figure 3.3 assumes an increase (+) in investment in capital goods, such as machinery, equipment, and technology, can increase productivity and stimulate economic growth (+). As the economy grows and the demand for goods and services increases (+), businesses may invest (+) even more in capital goods, leading to further increases in productivity (+).

Note that a positive link indicates a **direct relationship**. That is, if the cause increases, the effect increases above the expected level. Analogously, if the cause decreases, the effect decreases below the expected level (Sterman, 2000). A negative link indicates an **indirect relationship**. That is, if the cause increases, the effect decreases below the expected level. Similarly, if the cause decreases, the effect increases above the expected level (Sterman, 2000). More examples of CLDs are presented in Sections 8.2.1–8.2.3. We next turn our focus on the features of stock and flow diagrams.

3.2.2 *Stock and flow diagrams*

The **stock and flow diagram** method involves the mathematical development of a model by transferring a CLD to a stock and flow diagram, which captures the model structure and the relationships between the variables (Thaller, 2017). A **stock** is measured at one specific time instantaneously and describes a certain quantity at that point in time. On the other hand, a **flow** is measured over an interval of time. The corresponding diagram in Figure 3.4 outlines a systematic scheme of stock and flow diagrams:

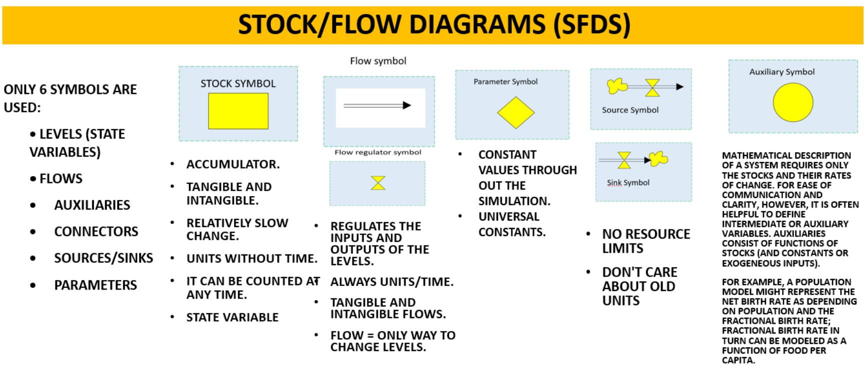

Figure 3.4. Scheme of stock and flow diagrams.

Observe that in Figure 3.4, the stocks represent the state or condition of the system, while the flows are action variables that modify the stocks and increase or decrease their quantities. This representation also contains auxiliaries and connectors, where the auxiliaries play the role of formulating the data and defining the flow equations, while the connectors represent the relationships between all the components of the system (Ghisolfi, 2017). Equation (3.1) accurately describes and assembles the stock and flow diagram in Figure 3.4:

$$\text{Inventory} = \text{Inflow Rate} - \text{Outflow Rate}. \tag{3.1}$$

Equation (3.1) thoroughly examines the following relationships between the inflow and outflow rates:

1. The outflow rate exceeds the inflow rate;
2. The inflow rate exceeds the outflow rate;
3. The two rates are equal.

Figures 3.5–3.8 present specific examples of applying the stocks and flow diagram in Figure 3.4 together with Eq. (3.1) to inventory, cash on hand, the quantity of students in a school or program, and acquiring knowledge, respectively.

Figure 3.5 displays an example of a stock and flow diagram describing the productions and sales of an inventory.

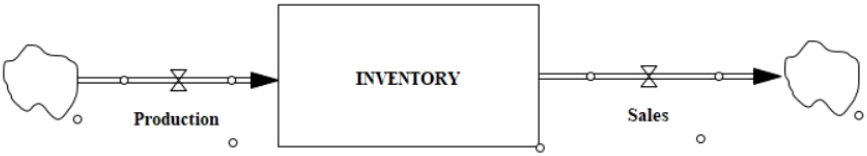

Figure 3.5. Stock and flow diagram of an inventory.

Note that in Figure 3.5, the inventory is represented as a stock, where the product is available for sale. On the other hand, the inflow to the stock is production and resembles the rate at which a new product is manufactured. Also, observe that sales are the outflow from the stock and describe the rate at which the product is sold to customers.

The inflow and outflow rates determine how quickly the stock (inventory) changes over time. First, the inventory will increase if the production rate exceeds the sales rate. Second, the inventory will decrease if sales exceed the production rate. The inventory will remain constant if the production and sales rates are equal. Observe that in Figure 3.5, Eq. (3.1) describes the difference between the production and sales rates.

Figure 3.6 displays an example of a stock and flow diagram representing the revenues and expenses of cash on hand.

Figure 3.6. Stock and flow diagram of cash on hand.

In Figure 3.6, the cash on hand is represented as a stock, which is the amount of money available for use. The inflow to the stock is revenue, which is the rate at which money comes in from sales, investments, or other sources. The outflow from the stock is the expense, which is the rate at which money is spent on operating costs, salaries, investments, and other expenses. The inflow and outflow rates determine how quickly the stock (cash on hand) changes over time. In fact, if the revenue exceeds the expenses, then the cash on hand will increase. On the other hand, if the expenses exceed the revenue, then the cash on hand will decrease. If the revenue is equal to the expenses, then the cash on hand will remain constant.

The inflow and outflow rates determine how quickly the stock of cash on hand changes over time. If the revenue exceeds the expenses, then the cash on hand will increase. This can occur if a business has a strong sales period or if they make a profitable investment. If the expenses exceed the revenue, then the cash on hand will decrease. This can happen if a business has higher than expected costs or if they experience a decline in sales. If the revenue and the expenses are equal, then the cash on hand will remain constant. Observe that in Figure 3.6, Eq. (3.1) describes the difference between the rates of revenue and expenses.

Figure 3.7 outlines an example of a stock and flow diagram presenting the quantity of students in a school or in a program.

Figure 3.7. Stock and flow diagram of the number of students.

In Figure 3.7, the student enrollment is represented as a stock, which is the number of students enrolled in a school or program. The inflow to the stock resembles the admission of students, which is the rate at which new students are admitted. The outflow from the stock presents the graduation of students, which is the rate at which students graduate. The inflow and outflow rates determine how quickly the stock (student enrollment) changes over time. If the admission rate exceeds the graduation rate, then student enrollment will increase. If the graduation rate exceeds the admission rate, then student enrollment will decrease. If the admission and graduation rates are equal, then student enrollment will remain constant.

The admission and graduation rates can have a direct impact on the size and composition of the student enrollment stock. If the rate of admissions is higher than the rate of graduations, the student enrollment stock will increase. Conversely, if the rate of graduations is higher than the rate of admissions, the student enrollment stock will decrease. If the rates of admissions and graduations are equal, the student enrollment stock will remain constant. By tracking and analyzing the rates of admissions and graduations, educational institutions can obtain more accurate insights into the dynamics of their student enrollment stock and make more precise decisions regarding recruitment, retention, and resource allocation. Observe that in Figure 3.7, Eq. (3.1) describes the difference between the admission and graduation rates.

Figure 3.8 portrays an example of information or knowledge that a person has learned and retained.

Figure 3.8. Stock and flow diagram of learned and retained knowledge.

In Figure 3.8, knowledge is represented as a stock, which is the amount of information that a person has learned and retained. The inflow to the stock is the acquisition of new knowledge, which is the rate at which an individual learns new information by reading, studying, or by encountering new experiences. The outflow from the stock is forgetting, which is the rate at which knowledge is lost over time due to lack of use, age-related memory decline, and other similar factors. More details on the stock and flow diagram presented in Figure 3.8 will be examined in Figure 8.11 in Section 8.2.2.

The inflow and outflow rates determine how quickly the stock (knowledge) changes over time. If the acquisition rate exceeds the forgetting rate, then the person's knowledge will increase. If the forgetting rate exceeds the acquisition rate, then the person's knowledge will decrease. If the acquisition and forgetting rates are equal, then the person's knowledge will remain constant. Observe that in Figure 3.8, Eq. (3.1) describes the difference between the rates of acquisition and forgetting.

For instance, suppose a student is studying for an exam. The student's stock of knowledge includes all the current information he/she learned in the course. The inflow to the stock is the new information he/she obtained while studying, and the outflow is the information he/she forgot over time due to a lack of regular use. If the studying and reviewing rates exceed the forgetting rate, then his/her knowledge stock will increase, resulting in a better performance in the exam. However, if the forgetting rate exceeds the studying and reviewing rates, then his/her knowledge stock will decrease, resulting in poor performance in the exam. By understanding the inflows and outflows that affect knowledge, the student can design his/her own self-assessment and make beneficial studying interventions, such as review sessions, in order to optimize performance.

Figures 3.5–3.8 guide us in understanding the basic concepts of stocks and flows within a business context. By understanding the inflows and outflows that affect a stock, we can make more accurate and precise predictions that describe the change over time and design interventions to monitor or optimize the behavior. For example, a business might increase production in order to build up inventory for a busy season or decrease production to prevent overstocking. Similarly, a business might adjust pricing or marketing strategies in order to increase sales and reduce inventory. Additional applications of stock and flow diagrams will be discussed in Sections 4.1.2–4.6.2, 5.1.3, and 8.2.2.

3.2.3 *The iceberg model*

The **iceberg model** is a systems thinking tool that can be used to help people understand the relationship between noticeable problems or events and underlying factors. It aims to determine the origin and underlying causes of problems. The iceberg model also assumes additional, unnoticeable factors that lead to identifying and detecting the hidden causes of problems. The iceberg model shifts and expands your experiences and intuitions beyond the standard events that are easily accessible to everyone. In fact, this model directs your focus to the following virtues:

1. Observing details that only you can see;
2. Detecting and correcting mistakes;
3. Asking the right questions;
4. Introducing new innovations to solve peculiar problems;
5. Promoting alternative thinking, representation, and solutions;
6. Paving a new learning path.

The iceberg model is also an effective tool that aids managers in obtaining a stronger grasp of particular behavior and dynamics occurring within an organization. This metaphor highlights the existence of underlying forces at play beneath the surface, which influence both individual behavior and the functioning of organizations.

By examining the interrelationships among the key variables, managers can gain further insights regarding the success or failure of their quality management initiatives. The internal organizational events and patterns can be easily noticed as the iceberg's portion visible above the water surface. On the other hand, the portion of the iceberg beneath the water surface represents a deeper understanding of how the system works. It is essential to note that these underlying characteristics should not be confused with interpersonal relationships within the organizational structure, which are oriented toward responsibility and authority.

In other words, the iceberg model suggests that only 10% of an organization's composition is visible above the surface level, while the remaining 90% is not easily noticeable. In particular, these are the underlying characteristics that influence the behavior of individuals within the organization and can significantly contribute to the varying functionality of organizations.

Utilizing the iceberg model reveals a more comprehensive understanding of the behavior and dynamics within an organization. By recognizing the underlying characteristics, managers can make informed decisions and take effective actions to manage the organization's functioning. Figure 3.9 presents the fundamental attributes of the iceberg model.

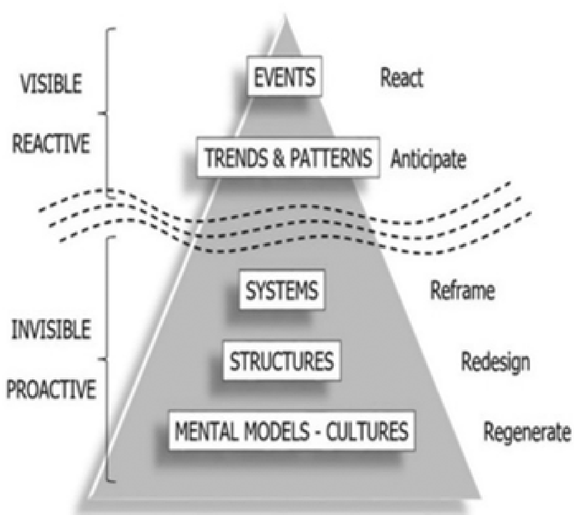

Figure 3.9. The iceberg model of systems thinking.

Figure 3.9 pinpoints the following levels, their characteristics, and their corresponding questions:

1. **The Event Level:** The event level is crucial because it is where people's experiences and observations occur. However, it is also important to remember that the event level is only a small part of the iceberg. There are typically many underlying factors that contribute to problems or events at this level.

   What has happened? What is happening right now?

2. **Patterns & Trends Level:** The pattern level is vital because it guides people to the broader picture. It also navigates to understanding how different events are related to each other and to identifying the beneficial trends and patterns in the problem-solving process.

   What has been happening over time? What are the trends? What changes have occurred?

3. **Structures & Systems:** The structure level is pertinent, as it unfolds the connection between different events, organizations, and structures. It also presents the interaction between different parts of a larger system.

   What is influencing these patterns? Where are the connections between patterns? Why is this happening?

4. **Mental Models:** The mental model level is beneficial as it leads people to understand why they think and behave in a certain way. It also reveals how their personal experiences and worldviews can impact the way they interpret and interact with the world.

   What values, beliefs, or assumptions shape the system?

More details about the iceberg model will be discussed in Section 8.1.1. These include the visible components presented in Figure 8.2 and the invisible components presented in Figure 8.3.

3.3 End of Chapter Summary

A variety of systems thinking tools are available to enhance our cognitive, critical thinking, and comparison skills, as they expand the horizons of our understanding of the categories of systems as well as their complexities. These tools also navigate us to divergent thinking and to designing our individualized learning paths, as each problem presents unique characteristics and often leads to a non-standard and individualized solution. Systems thinking tools also train us to detect the similarities and contrasts between different systems, as well as the similarities and contrasts in problem-solving techniques.

Examples of simple methods include action research and the 80/20 rule. On the other hand, the Forrester effect and agent-based modeling are examples of complex methods. Complex methods analyze the long-term effects and assume external factors. In particular, the Forrester effect presents this phenomenon by delivering equations which describe the accumulations that occur over time. These include inventory accumulations. In Chapter 4, we describe six patterns of behavior that reveal contrasting examples of simple vs. complex methods.

3.4 Further Thoughts

1. In Section 3.1.1, we discussed the fundamentals as well as the cyclical and iterative nature of action research. How is action research related to Kolb's experiential learning cycle? In particular, what are the interconnections between Figures 1.10 and 3.1?
2. In Section 3.2, we discussed the fundamentals of soft vs. hard tools. Can we consider the TOC as a soft tool and the Forrester effect and Ashby's law as hard tools?
3. In Section 3.2.1, we discussed the techniques and applications of causal loops. Assemble a CLD that describes the **return on investment**, including the amount invested and the amount gained on the investment.

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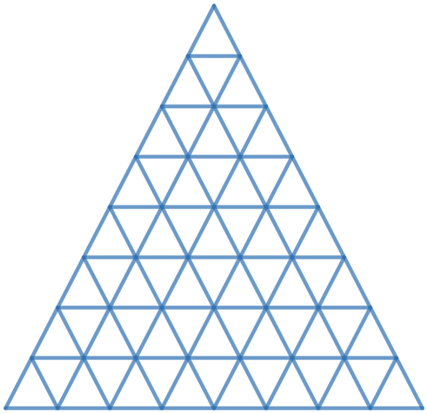
Chapter 4

Learning by Deciphering Patterns

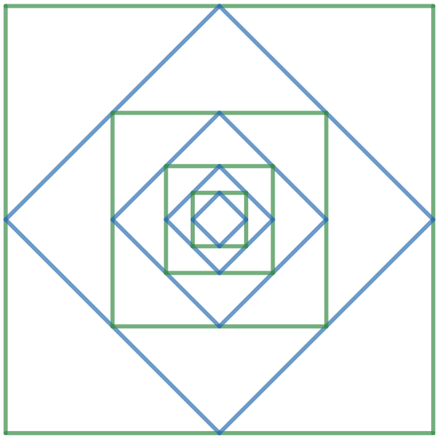
We define a **pattern** as "a repeated design or a recurring sequence, an ordered set of numbers, shapes, or other mathematical objects arranged according to a rule." Recognition and formulation of patterns is an essential part of the learning process, as we notice patterns during specific instances such as: traffic patterns, musical patterns, behavioral patterns in psychology, patterns in decision-making, nature's formation patterns, weather patterns (winds, storms, waves, etc.), patterns in languages, patterns in computer programs, patterns in signals and signal processing, decorative patterns, architectural patterns, and mathematical patterns.

Repeated observations or observing patterns many times lead you to systematically identify the patterns' fundamentals and formulations. After numerous repetitions, we start to notice and understand how and when patterns emerge and their distinct traits and applications. Our aims are to examine and design new systematic structures and formulations, leading to effective two-directional communication, creative, divergent, and convergent thinking. Our further intent is to develop and enhance comparison skills that discern the similarities and contrasts between patterns.

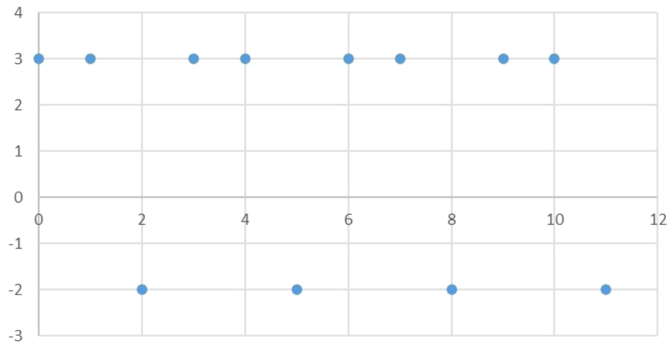
Next, we get acquainted with examples of assorted geometrical patterns. The consequent diagram traces a system of triangles replicated at the same scale, with one triangle in the first row, three triangles in the second row, five triangles in the third row, etc.



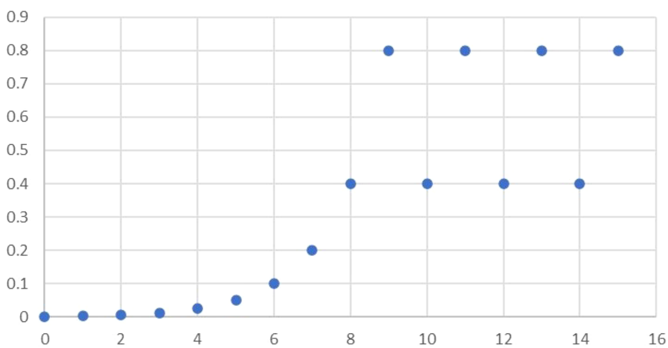
The following sketch presents a system of diminishing green and blue squares.



Note that the green squares arise in horizontal and vertical directions, while the blue squares appear in diagonal directions. The following graph traces a descending step-shaped period-3 cycle.



Observe that the period-3 cycle emerges as a descending step-shaped pattern as the first two terms of the cycle are at the top, while the third term of the cycle descends. The consequent sketch presents a period-2 cycle with eight ascending transient terms.



Note that the eight ascending transient terms transition to the period-2 pattern. We next turn our focus to the examination of the six patterns of behavior within the dynamics of change. Dynamics of change awareness is critical to note, as systems are dynamic and constantly changing. In fact, understanding and detecting the drivers of change in a system is essential to accurately tracing its behavior. These include mission changes, strategic changes, operational changes, and technological changes. Figure 4.1 outlines the six patterns of behavior (Sterman, 2000).

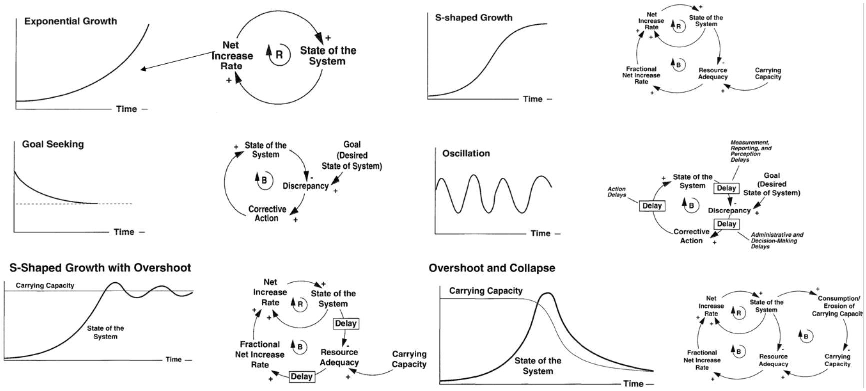


Figure 4.1. The six modes of behavior.

The following six sections elaborate on further details of the six patterns of behavior: exponential growth, goal seeking, S-shaped growth with overshoot, S-shaped growth, oscillation, and overshoot and collapse. We also examine the six patterns of behavior together with the casual loop diagrams and the stocks and flows diagrams. Section 4.1 will explore the traits of exponential growth.

4.1 Exponential Growth Pattern

Exponential growth is a fundamental pattern of behavior that naturally arises in many natural and human-designed systems. In fact, exponential growth occurs when a quantity's rate of change is proportional to its current value. This means that as the quantity increases, the growth rate also increases, which leads to a rapidly accelerating growth rate. Conversely, as the quantity decreases, the rate of decay accelerates as well. Figure 4.2 presents the shape and dynamics of exponential growth (Sterman, 2000).

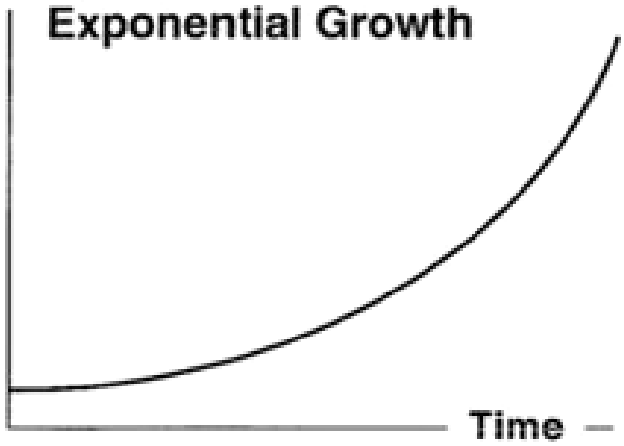


Figure 4.2. The exponential growth curve.

Observe that in Figures 4.1 and 4.2, the exponential growth curve appears as an "ascending hockey-stick-shaped growth curve," where the rate of growth commences with a slow start but rapidly accelerates over time. This implies that initially, the quantity grows slowly but then begins to escalate at an increasingly rapid rate and eventually reaches very high levels.

Exponential growth is characterized by a constant growth rate, which is equal to the net increase rate of the system. The net increase rate is the difference between the inflow rate and the outflow rate of the system and determines the rate at which the quantity accumulates over time. The quantity grows exponentially if the net increase rate is positive. The quantity decays exponentially if the net increase rate is negative.

4.1.1 *Causal loop diagram*

In the context of exponential growth, the causal loop diagram in Figure 4.3 includes variables such as "state of the system" and "net increase rate" (Sterman, 2000).

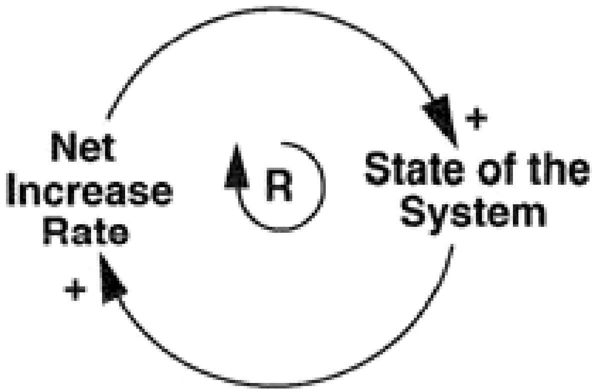


Figure 4.3. Exponential growth: Causal loop diagram.

In Figure 4.3, the state of the system represents the quantity that is growing or decaying exponentially, while the net increase rate represents the difference between the inflow and outflow rates of the system. The arrows indicate the relationships between these variables. An arrow from the state of the system to the net increase rate emphasizes that the current value of the state of the system determines the net increase rate. There is also an arrow pointing from the net increase rate to the state of the system, which indicates that the state of the system changes in response to the net increase rate.

The exponential growth's causal loop diagram in Figure 4.3 can be applied to population dynamics, economics and business, healthcare and epidemiology, and environmental science. In population dynamics, if the birth rate increases, then the population increases. In economics and business, a net increase in customers attracts more customers and leads to further increases in sales (e.g., the sales of iPhones). An example in economics and business is the spread of a crisis, such as the Great Depression. The spread of the Black Plague, swine flu, and COVID-19 are examples in healthcare and in epidemiology. In addition, the spread of forest fires can be cited as an example in environmental science.

4.1.2 *Stocks and flows diagram*

In the context of exponential growth, the stocks and flows diagram in Figure 4.4 portrays an example of infected individuals during a pandemic.

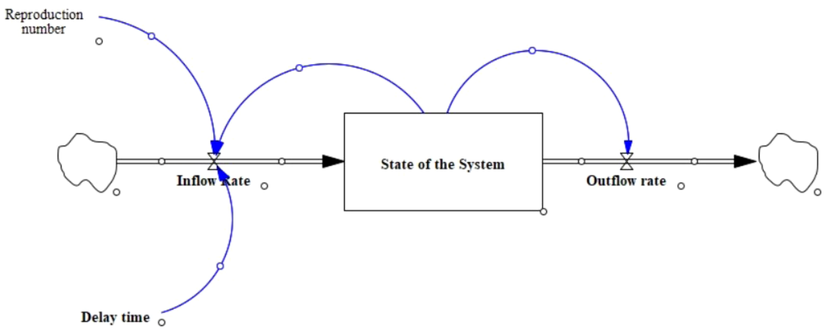


Figure 4.4. Exponential growth: Stocks & flow diagram.

In Figure 4.4, the stock represents the number of infected individuals, which occurs at a specific time. The inflow to the stock is the rate at which new individuals become infected. The outflow from the stock is the rate at which infected individuals either recover or die. Observe that in Figure 4.4, Eq. (3.1) describes the difference between the inflow and outflow rates. In addition, the reproduction number describes the average number of individuals that an infected individual will infect over the course of their infectious period. The delay parameter represents the time span of the infectious period.

More supplemental details about the exponential pattern are elaborated upon in Section 9.5.1.

4.2 Goal-Seeking Pattern

In dynamic systems, **goal seeking** is the process of finding an optimal solution to a problem by adjusting the values of certain variables. In particular, it involves outlining the objectives and then using trial-and-error methods or algorithms to determine the solutions that satisfy the goals. In this context, goal seeking can be used for modeling complex system dynamics over time. These include economic growth, population trends, and environmental issues. The analysis is conducted by studying and understanding the primary roots of the problem rather than simply considering the symptoms that are only visible at the surface (Sterman, 2000). Figure 4.5 presents the **first step of goal seeking** and describes the shape and dynamics of goal seeking (Sterman, 2000).

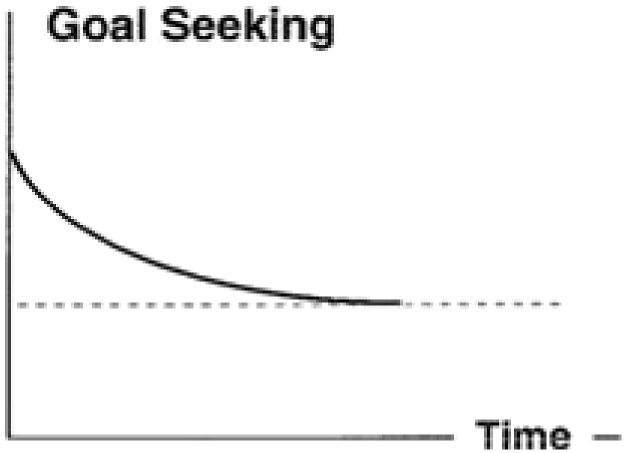


Figure 4.5. Goal-seeking curve.

Note that the goal-seeking curve in Figure 4.5 appears as a "descending hockey-stick-shaped growth curve." The goal-seeking pattern of behavior can be discovered in numerous types of dynamic systems, such as businesses, ecosystems, and even individual decision-making. Applications of the goal-seeking pattern arise in business, healthcare, education, and ecosystems.

For instance, in **business**, a company aims to achieve the goal of increasing its market share by a certain percentage in a given year. The company's management team then develops strategies and tactics to achieve this goal, which may include launching a new product line, expanding into new markets, or increasing advertising spendings. The company will track its progress toward the goal and make the necessary adjustments to ensure that it achieves the expected outcomes. Also, the company may set a revenue goal for the quarter, take actions such as adjusting prices or implementing marketing strategies, and evaluate the results to determine if the goal has been accomplished. If not, the company may adjust its actions and try again until the revenue goal is achieved.

In **healthcare**, a hospital may aim to reduce its readmission rate for a specific medical condition. The hospital then develops protocols and programs to ensure that patients receive appropriate care prior to being discharged and ensure follow-up care afterward. The hospital will then carefully observe the readmission rate and adjust its programs and protocols if necessary in order to achieve the desired outcomes.

In **education**, a school district orients toward enhancing its students' reading proficiency. The district plans to develop strategies and interventions to help students improve their reading skills. These include literacy tutoring or implementing a new reading curriculum. The district then carefully monitors the reading proficiency of its students and adjusts its strategies and interventions in order to achieve the desired goals.

In **ecosystems**, the goal-seeking behavior emerges when species adapt and evolve to changing environmental conditions in order to survive and reproduce.

In **individual decision-making**, the goal-seeking pattern of behavior is evident when individuals set goals, take actions to achieve the goals, and adjust their behaviors based on the feedback from the environment.

4.2.1 *Causal loop diagram*

Figure 4.6 shows the **second step of goal seeking**, where the state of the system refers to the current condition of the system (Sterman, 2000).

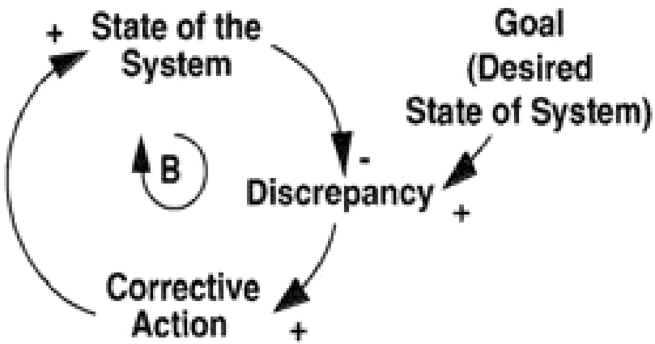


Figure 4.6. Goal-seeking causal loop.

In Figure 4.6, the discrepancy occurs due to the difference between the current state and the desired oriented state of the system. The corrective action refers to the steps taken to reduce this discrepancy and adjust the system more accurately and closer to the desired oriented state.

The arrows in Figure 4.6 indicate the causal relationships between these variables. The state of the system influences the size and direction of the discrepancy, which in turn determines the implemented corrective action. The corrective action then influences the state of the system, which can either reduce or exacerbate the discrepancy, depending on the effect.

4.2.2 *Stocks and flows diagram*

In the context of goal seeking, the stocks and flows diagram in Figure 4.7 illustrates the "inventory" stock as the amount of inventory currently held by a business, which is affected by the input of supply from orders placed and the output of demand from customers.

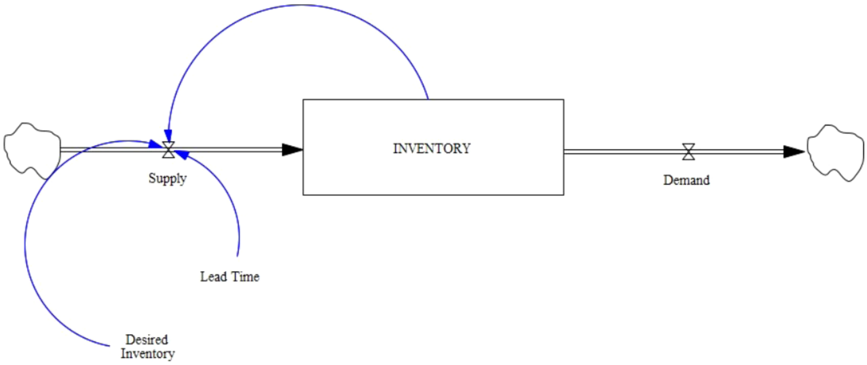


Figure 4.7. Goal seeking: Stocks & flow diagram.

Observe that in Figure 4.7, Eq. (3.1) describes the difference between the supply and demand rates. In addition, the desired inventory and lead time affect the supply rate.

More supplemental details about the goal-seeking pattern are elaborated upon in Section 9.5.2.

4.3 S-Shaped Growth with Overshoot Pattern

In dynamic systems, **S-shaped growth with overshoot** is a type of behavior in which an initial input increases at a slow rate and then rapidly accelerates as it approaches its maximum. This often emerges as an S-shaped curve when graphed out on paper and can transform into exponential growth if left unchecked. This then implies that minor and unnoticeable changes may have significant effects after some time period. It is quite a common phenomenon in epidemics, innovation diffusion, or the growth of new products due to how quickly they spread through populations once certain thresholds are reached. Figure 4.8 presents the **first step of the S-shaped growth with overshoot** and describes the shape and dynamics of this pattern (Sterman, 2000).

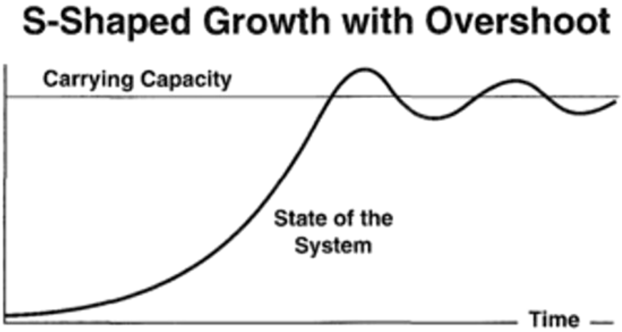


Figure 4.8. S-shaped growth with overshoot curve.

The S-shaped growth with oscillation presented in Figure 4.8 comes about in several types of dynamic systems. These include ecosystems, economies, and individuals' behaviors as well. For example, in an ecosystem, a species may experience a period of rapid population growth due to favorable climatic conditions. However, resource limitations, such as food or space, may lead to an eventual decline or even collapse in the population.

In an economic context, a business may experience rapid growth due to increased demand or new products. However, resource limitations, such as lack of funding or skilled labor, may lead to an eventual decline in growth or even bankruptcy.

In an individual's behavior, the S-Shaped Growth with Overshoot mode of behavior can be noticed in situations such as addiction or overconsumption, where the individual experiences a period of initial enjoyment or reward, which is consequently followed by negative consequences due to resource limitations or other constraints. Next, we discuss additional applications of the S-shaped growth with oscillation in business, education, and healthcare.

In **business**, suppose that a retail chain experiences rapid growth and decides to open new stores in more locations. As the company expands, its growth begins to slow down due to market saturation and competition. The oscillations and overshoot occur as the management aims to maintain the initial growth rate and may decide to continue opening new stores beyond the market's carrying capacity. As a result, some of the new stores may struggle to generate sufficient revenue to survive. Therefore, the company may have no choice but to close the underperforming locations and re-evaluate its expansion strategy. In this scenario, the growth of the retail chain traces an S-shaped curve with overshoot presented in Figure 4.8, as the company eventually stabilizes and adapts to a more sustainable growth rate.

Massive open online courses (MOOCs) are an example of S-shaped growth with overshoot in **education**. During the early phase of MOOCs, platforms such as Coursera, edX, and Udacity experienced exponential growth as more people sought accessible and affordable education. However, the growth rate impeded as the market became saturated and the limitations of MOOCs became apparent (such as low completion rates). In some cases, providers may have expanded their course offerings too quickly, which resulted in an overshoot and oscillations and hence the consolidation and refinement of their offerings.

The adoption of electronic health records (EHRs) is an example of S-shaped growth with oscillation in **healthcare**. Initially, EHRs were rapidly adopted by healthcare providers to improve patient care and streamline administrative processes. However, the growth was impeded as the EHR market matured and became saturated. In some instances, healthcare providers may have implemented EHR systems too quickly or without adequate training and support. This led to an overshoot in the system's capacity. This can result in reduced efficiency, increased costs, and even potential negative impacts on patient care. In response, the industry has shifted its interests toward refining and optimizing EHR systems by focusing on interoperability, usability, and security.

4.3.1 *Causal loop diagram*

Figure 4.9 illustrates the **second step of S-shaped growth with overshoot**, in which the state of the system refers to the current condition of the system (Sterman, 2000).

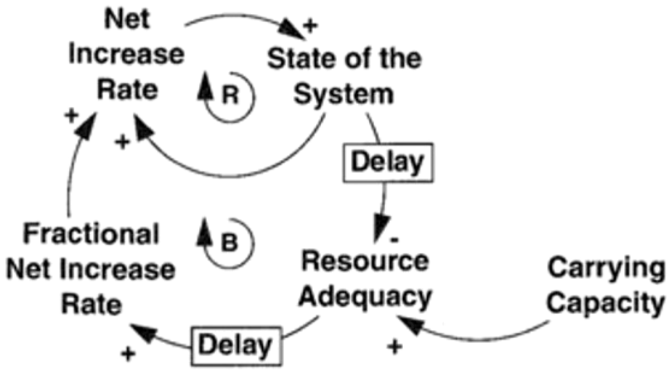


Figure 4.9. S-shaped growth with overshoot causal loop.

In the case of S-shaped growth with overshoot, the key variables in Figure 4.9 are the net increase rate, state of the system, delay, resource adequacy, fractional net increase rate, and carrying capacity.

The **net increase rate** is the rate at which the system is growing while taking into account both additions (births, immigration, etc.) and subtractions (deaths, emigration, etc.).

The **state of the system** represents the current condition or size of the system (e.g., population, market size, etc.).

Delays can occur in the system due to various factors, such as the required time to recognize changes in the system or implement corrective actions.

Resource adequacy indicates the extent to which available resources can support the current state of the system.

The **fractional net increase rate** is the net increase rate as a fraction of the state of the system, which can be interpreted as the system's relative growth rate.

Carrying capacity is the maximum level that the system can sustain without depleting resources or experiencing other negative consequences.

4.3.2 *Stocks and flows diagram*

In the context of the S-shaped growth with overshoot, the stocks and flows diagram in Figure 4.10 represents the population of a species in terms of birth rate and death rate.

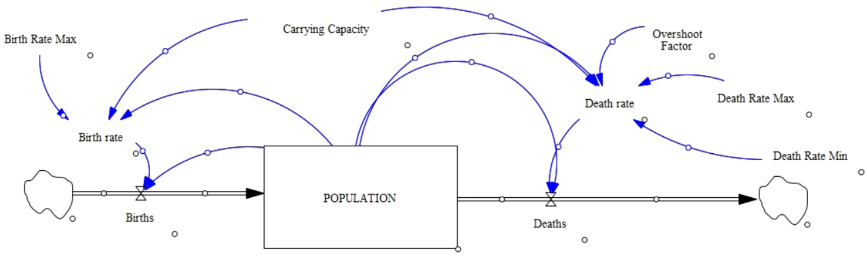


Figure 4.10. S-shaped growth with overshoot: Stocks & flow diagram.

Observe that in Figure 4.10, Eq. (3.1) describes the difference between the birth and death rates. Also, note that the population is the stock and the flows are the birth and death rates. The birth and death rates are the auxiliary variables measured in people per year. Additional variables are the carrying capacity (K), the overshoot factor (OF), the birth rate max (BRM), the death rate min (DRM), and the death rate max (DRX).

More supplemental details about the S-shaped growth with overshoot pattern are elaborated upon in Section 9.5.3.

4.4 S-Shaped Growth Pattern

In dynamic systems, the **S-shaped growth pattern** is beneficial in systems thinking as it can aid individuals and organizations to understand and trace complex systems' behavior over time. By analyzing the underlying drivers of growth and the limiting factors, individuals and organizations can make more accurate and precise decisions and future planning. Figure 4.11 presents the shape, characteristics, and dynamics of the S-shaped growth (Sterman, 2000).

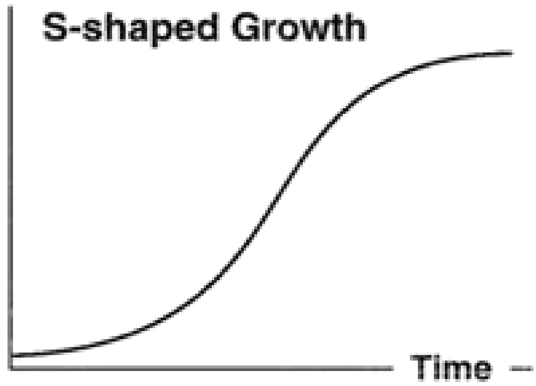


Figure 4.11. The S-shaped growth pattern curve.

In Figure 4.11, the S-shaped growth pattern curve outlines the following three phases:

Slow growth is the initial phase, as the growth rate is slow due to limited resources and other constraints. This phase is also known as the **lag phase**, or the **start-up phase**.

Rapid growth is the next phase as the system gains momentum, resources become available, and the growth rate rapidly increases. This phase is also known as the **acceleration phase**, or the **growth phase**.

Saturation is the final stage of the system. This occurs when the system reaches a limiting factor or resource constraints prevent further growth. At this point, the growth rate levels off, while the system enters the equilibrium phase or the stability phase. This phase is also known as the **deceleration phase**, or the **plateau phase**.

Now, we present some applications of the S-shaped growth pattern in business, education, and healthcare. In **business**, the S-shaped growth describes a pattern of the slow initial growth followed by rapid expansion before reaching a plateau. A new tech start-up is an example of such growth. The growth may appear initially marginal as the company develops and refines its product. Once the product gains traction, the growth can increase rapidly and exponentially. Eventually, the growth levels off as the market becomes saturated. Companies such as Uber and Airbnb are examples of such growth.

In **education**, the S-shaped growth pattern can be noticed during the learning process or learning curve of a new theme, concept, or skill. In fact, students can often experience slow progress initially as they attempt to grasp new concepts and ideas. As students become more familiar with the concepts, their progress rate accelerates until they reach a point where they achieve a strong grasp of the material. Learning a foreign language and learning to play a musical instrument are examples of such learning processes. This phenomenon occurs with slow initial progress and eventually accelerates once a stronger grasp of the fundamentals is gained.

In **healthcare**, the S-shaped growth can arise in the adoption of new medical treatments or technologies. Initial slow progress is experienced while the doctors and patients become familiar with the new treatment. The adoption rate accelerates as more evidence emerges about its effectiveness. Eventually, the treatment becomes widely accepted as the process gradually reaches its plateau. For example, the adoption of robotic surgery experienced a slow initial start, but its application gradually increased in numerous hospitals.

4.4.1 *Causal loop diagram*

Figure 4.12 reveals the **second step of the S-shaped growth**, in which the state of the system refers to the current condition of the system (Sterman, 2000).

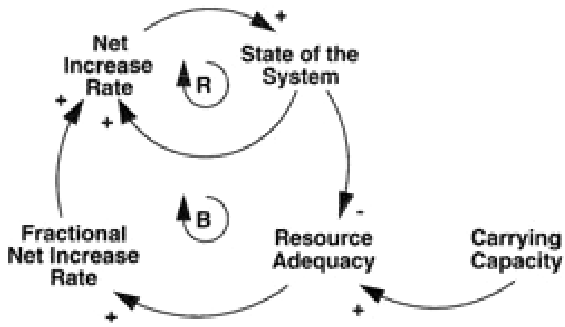


Figure 4.12. S-shaped growth causal loop.

The casual loop diagram in Figure 4.12 traces the following features of the S-shaped growth pattern.

The **net increase rate** (NIR) variable represents the difference between the number of new adopters and the number of abandoners in a given time period. NIR is influenced by the fractional net increase rate and resource adequacy.

The **state of the system** variable represents the current level of adoption in the system. The state of the system is influenced by the NIR and the carrying capacity.

The **fractional net increase rate** (FNIR) variable represents the proportion of potential adopters who are actually adopting the innovation. FNIR is influenced by the perceived relative advantage, compatibility, complexity, trialability, and observability of the innovation.

The **resource adequacy** variable represents the availability of resources, such as funding, personnel, and infrastructure, which support adoption. Resource adequacy is influenced by the level of investment in innovation.

The **carrying capacity** variable represents the maximum level of adoption that can be sustained in the system over time. Carrying capacity is influenced by the availability of resources and the level of competition.

Observe that a reinforcing feedback loop occurs at the heart of the S-shaped growth pattern, where the NIR and the state of the system are the two related variables. In fact, when the NIR is positive, then the state of the system increases. This then leads to a higher NIR and a virtuous cycle that drives rapid growth.

On the other hand, as the system approaches its carrying capacity, a balancing feedback loop emerges, while the reinforcing feedback loop begins to fade and its effect gradually weakens. The state of the system and the FNIR are the two variables of the loop. As the state of the system approaches the carrying capacity, the FNIR decreases, then impedes the NIR, and hence leads to slower growth and eventual saturation. The causal loop diagram for the S-shaped growth pattern shows how different variables interact with each other to produce the characteristic growth and saturation pattern. This model can be very beneficial to understand and monitor growth more accurately in diverse systems, such as business, education, healthcare, and supply chains.

4.4.2 *Stocks and flows diagram*

In the context of the S-shaped growth pattern, the stocks and flows diagram in Figure 4.13 portrays an example of infected individuals during a pandemic.

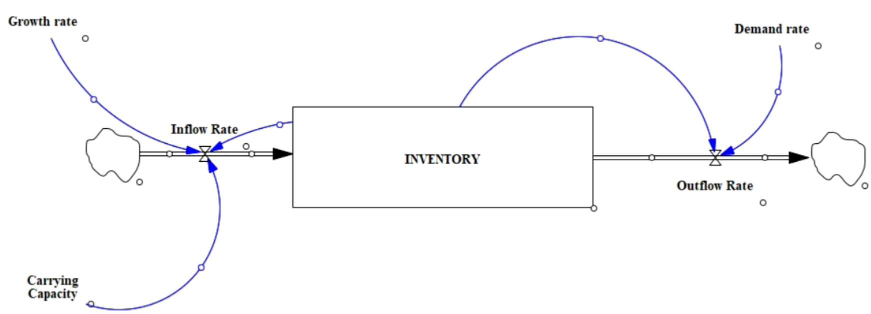


Figure 4.13. S-shaped growth: Stocks & flow diagram.

Observe that in Figure 4.13, Eq. (3.1) describes the difference between the inflow and outflow rates. In addition, the stock represents the current amount of available resources or units. The **inflow rate** corresponds to the number of units being added to the inventory over time, driven by factors such as production, innovation, and market demand. The **outflow rate** represents the number of units being removed from the inventory, influenced by factors such as consumption, obsolescence, and competition.

The **growth rate** is the inflow rate of units into the inventory. This can be affected by factors such as product development, marketing efforts, and overall market growth.

The **carrying capacity** signifies the maximum number of units that can be sustained in the inventory without causing negative consequences such as oversupply and resource depletion. It can be influenced by factors such as production capacity, market saturation, and resource availability.

The **demand rate** is the rate at which units are consumed or required by the market. This is influenced by factors such as consumer preferences, pricing, and market trends.

More supplemental details about the S-shaped growth pattern are elaborated upon in Section 9.5.4.

4.5 Oscillation Pattern

The **oscillation pattern** in dynamic systems is a type of behavior where the values or variables within the system fluctuate between two extremes (crest and trough) over time. This can arise as an alternating pattern, where each extreme (crest or trough) is reached before reversing direction. Oscillations often arise as a result of feed back loops. In fact, this oscillatory phenomenon occurs when changes to one variable cause related changes to other variables. This then causes further adjustments that eventually lead back to the full cycle again (Sterman, 2000).

For example, the population of a particular species in an ecosystem can exhibit oscillatory behavior. The population may increase due to favorable conditions, such as abundant food and shelter. However, resources become scarce as the population grows, which then leads to a decline in the population. Resources become more available as the population decreases, which then leads to a subsequent increase in the population. This cycle of growth and decline can repeat and hence emerge as an oscillatory pattern.

Figure 4.14 presents the shape, characteristics, and dynamics of the oscillation pattern (Sterman, 2000).

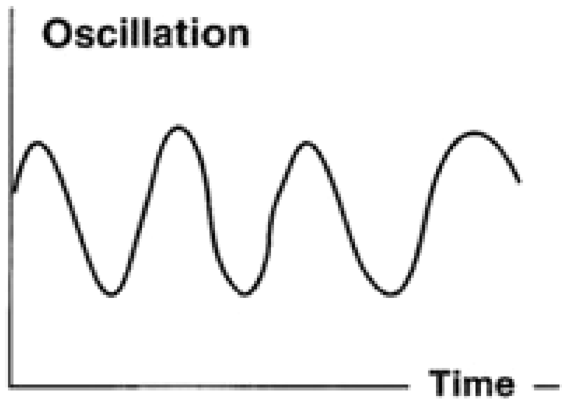


Figure 4.14. The oscillation pattern curve.

Oscillations can also occur as business cycles in economic systems. The economy may experience periods of growth, followed by a downturn or recession, and then recover again. This cyclical pattern can be driven by various factors, such as changes in consumer demand, shifts in government policies, and fluctuations in global markets.

Periodic fluctuations, seasonal oscillations, and stock market oscillations often naturally emerge as **business cyclical patterns**. Periodic fluctuations arise in economic growth and are typically characterized by alternating periods of expansion and contraction (growth and recession). These cycles are influenced by factors such as changes in consumer demand, government policies, and global economic conditions.

Seasonal oscillations emerge as numerous businesses experience predictable fluctuations in sales due to seasonal factors. For example, retail businesses might see increased sales during the holiday season, while travel agencies might experience higher demand during vacation periods.

Stock market oscillations come about as the stock market exhibits oscillatory behavior as share prices rise and fall in response to various factors. These factors include investor sentiment, economic indicators, and corporate news. Technical analysts study these patterns to make more accurate and precise, informed trading decisions.

Student performance oscillations, enrollment cycles, and oscillations in educational policies can be encountered in **education systems** at various levels. Students' academic performance can oscillate during the academic year or during their academic careers. Performance can be influenced by factors such as changes in difficulty levels, personal circumstances, motivations, and the quality of teaching.

Schools and universities often experience enrollment oscillations due to demographic trends, economic conditions, and career orientations. These factors can impact the schools' and universities' resource allocations and strategic planning.

Departments of education, schools, and universities may periodically revise policies, curricula, and teaching methods. Oscillations in educational practices and standards can come about as a consequence of educational reforms and revisions. Educational reforms and revisions are implemented to accommodate students' new learning styles, experiential learning, internal cultural changes, international influences, technical influences, and economic and career trends.

4.5.1 *Causal loop diagram*

Figure 4.15 reveals the **second step of the oscillation**, in which the state of the system refers to the current condition of the system (Sterman, 2000).

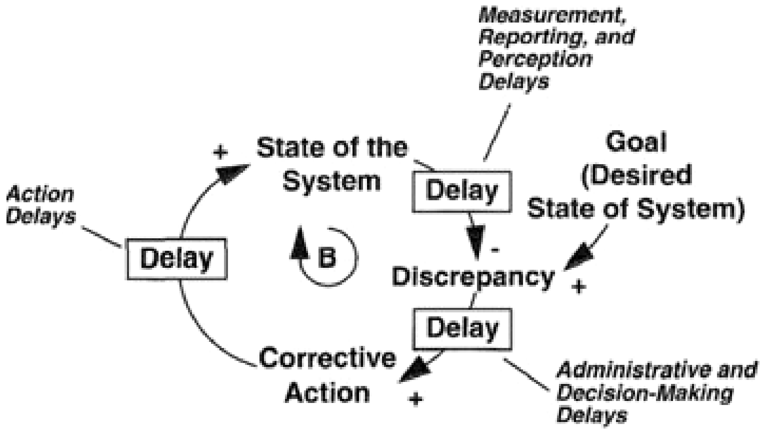


Figure 4.15. Oscillation: Causal loop.

The casual loop diagram in Figure 4.15 outlines the desired goal or state that the system aims to achieve. The scheme includes the state of the system, measurement, reporting, corrective action, and delays. Examples of delays include perception delays, administrative and decision-making delays, and action delays.

The state of the system is the current condition of the system, which is monitored and compared to the actual desired goal. Measure ment is the process of obtaining the state of the system's data. Reporting is the process of presenting the measured data to relevant stakeholders. **Perception delay** is the amount of time it takes for stakeholders to interpret and understand the reported information. **Administrative and decision-making delay** is the time it takes for stakeholders to decide on the appropriate corrective action in response to the perceived state of the system. **Action delay** is the amount of time it takes for the corrective action to be implemented and have an impact on the system. **Delay** is the overall time lag between the initiation of corrective action and the change in the state of the system. Corrective action is the necessary action taken to adjust the system's state toward the desired goal.

In **business**, for example, the goal or desired state of the system is the optimal inventory level that focuses on the balance between customer demand and warehousing costs. The state of the system is the current inventory level in the company's warehouse. Measurement is the process of tracking and recording inventory levels on a regular basis. Reporting is the inventory report that is shared with management and provides an overview of current stock levels. Perception delay is the amount of time it takes for management to review and interpret the inventory report. Administrative and decision-making delay is the amount of time it takes for the management to decide how to adjust inventory levels, such as ordering more stock or offering promotions to clear excess inventory. Corrective action is implemented by the management to bring inventory levels closer to the optimal level, such as placing new orders or launching marketing campaigns to increase sales. Action delay is the amount of time it takes to make revisions and impact inventory levels. These include the lead time for new stock to arrive or the time it takes for a marketing campaign to generate sales. Delay is the overall time lag between the initiation of corrective action and the change in the inventory level.

In this example, the management aims to maintain an optimal inventory level. The negative feedback loop shows that management makes adjustments and revisions as the inventory level deviates from the goal. However, the delays in perceiving, deciding, and implementing these actions can cause inventory levels to oscillate, which then result in stockouts or excess inventory. The company can achieve better inventory control and minimize oscillations by accurately understanding and managing these delays.

In **education**, the goal is to improve the overall literacy rate in a region from 70% to 90% within five years. The state of the system is the 70% current literacy rate in the region, which is monitored and compared to the goal. Measurement is the data that the department of education collects on the literacy rate in the region by conducting surveys and assessments. Reporting is presented using measured data to relevant stakeholders, including policymakers, educators, and parents. Perception delay is the amount of time it takes for the stakeholders to interpret and understand the reported information about the current literacy rate and what it takes to achieve the goal. Administrative and decision-making delays occur as it takes some time for the stakeholders to decide on the appropriate corrective action, such as investing in teacher training or implementing new teaching methods. The department of education takes corrective action, such as investing in teacher training, implementing new teaching methods, and increasing access to educational resources, to improve the literacy rate in the region. Action delays emerge as it takes some time to implement teacher training, provide educational resources, and implement new teaching methods. Delay is the overall time lag between the initiation of corrective action and the change in the state of the system, which is the improvement in the literacy rate, and could be several years.

4.5.2 *Stocks and flows diagram*

In the context of the oscillation pattern, the stocks and flows diagram in Figure 4.16 represents an oscillation system where changes in inventory lead to changes in production rate, which then leads to changes in inventory and so on.

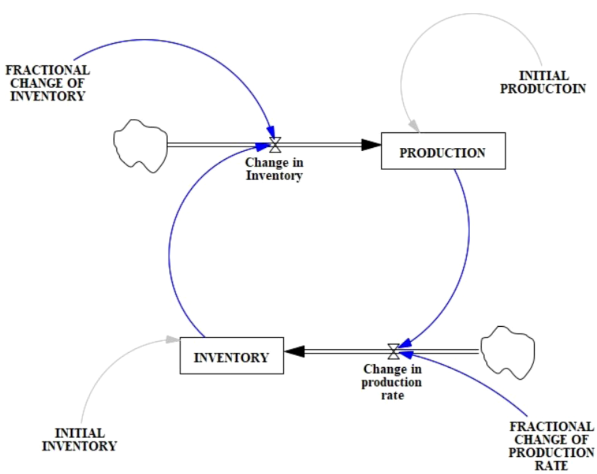


Figure 4.16. Oscillation: Stocks & flow diagram.

Observe that in Figure 4.16, Eq. (3.1) describes the difference between the change in production rate and the change in inventory rate. Also, note that the stocks are the inventory and production, while the flows are the change in the production rate. The change in inventory and variables are the fractional change in inventory, initial production, initial inventory, and the fractional change in the production rate. In particular, the variables fractional change in inventory and fractional change in production rate determine the rate and magnitude of the oscillation. The initial values of initial production and initial inventory determine the starting point of the system.

This oscillation model has practical applications in the fields of inventory management and production planning. In particular, this model can be used to simulate and predict the behavior of inventory and production rates in a manufacturing or distribution system. The model can be used to identify optimal inventory levels and production rates that minimize costs and maximize profits by adjusting the initial values of the variables, such as the initial production rate and inventory levels, and the fractional changes in inventory and production rate.

For example, a business or corporation can apply this model to simulate different scenarios for inventory and production rates based on different demand levels, production costs, and other factors. By analyzing the outputs of the model, a business or corporation can identify the most efficient inventory and production policies to achieve the desired outcomes. In addition, the model can be used to monitor and control inventory and production levels in real time, enabling the company to adjust its operations as needed to maintain optimal levels.

In **education**, the oscillation model can be applied to optimize the production and inventory of educational resources, such as textbooks, digital learning tools, and educational supplies. The model can be used to simulate different scenarios for the demand and supply of educational resources based on student enrollment, curriculum changes, and budget constraints. By adjusting the initial values of the variables and analyzing the outputs of the model, schools, universities, and departments of education can identify the most efficient inventory and production policies to ensure that they have the necessary resources to meet the students' needs while minimizing the costs. A school district can apply this model to determine the optimal number of textbooks and digital learning tools to order for the upcoming school year based on the projected student enrollment and curriculum changes.

In **healthcare**, the oscillation model can be applied to optimize the inventory and production of medical supplies and equipment, such as personal protective equipment (PPE), medications, and medical devices. The model can be used to simulate different scenarios for the demand and supply of medical supplies and equipment based on patient volumes, disease outbreaks, and budget constraints. By adjusting the initial values of the variables and analyzing the outputs of the model, healthcare organizations can identify the most efficient inventory and production policies to ensure that they have the necessary supplies and equipment to meet patient needs while minimizing costs. A hospital can use this model to determine the optimal number of PPE and medications to order for the upcoming flu season based on the projected patient volumes and disease outbreaks.

More supplemental details about the oscillation pattern are elaborated upon in Section 9.5.5.

4.6 Overshoot and Collapse Pattern

In dynamic systems, **overshoot and collapse** describe a specific pattern when an initial value rapidly ascends before eventually reaching its maximum and then quickly descends back to below the original starting point. The overshoot indicates how far past its peak the dynamics occurs before collapsing again. This pattern frequently appears in epidemics or innovation diffusion due to how quickly they spread through populations once reaching certain thresholds. Figure 4.17 presents the shape, characteristics, and dynamics of the overshoot and collapse pattern (Sterman, 2000).

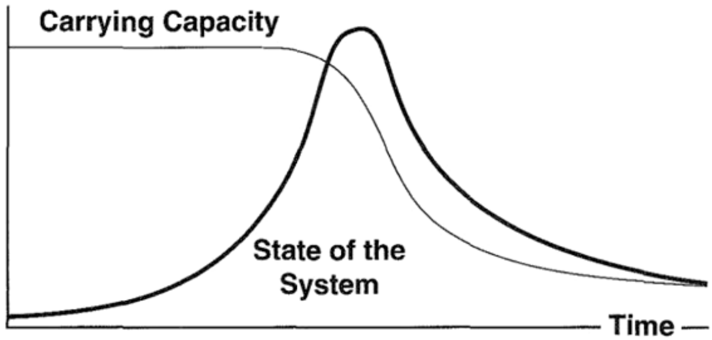


Figure 4.17. The overshoot & collapse curve.

Note that other factors, such as economic bubbles or unsustainable growth patterns, can affect the threshold. However, their effect eventually leads to a crash at some point (Sterman, 2000).

The collapse of the cod fishery industry in Newfoundland during the early 1990s is an example of overshoot and collapse. The fishing industry rapidly expanded as a result of technological advances and high demand, which then led to overfishing and the depletion of the cod population. Despite the warnings from scientists and regulators, the industry continued to expand until it collapsed, which then resulted in job losses and economic hardship for numerous communities in the region.

In **business**, a company may experience overshoot by expanding too quickly. Such expansions include accepting too many new projects or investments at the same time, beyond its carrying capacity. This can lead to a temporary surge in profits and growth, which may not be sustainable over the long term. For example, a company might expand its manufacturing capacity beyond its ability to source raw materials, which then leads to a temporary surge in production and a gradual decline in product quality and supply chain disruptions.

A company may experience collapse if its growth is established on a shaky and unreliable foundation. In fact, the company may eventually collapse under its own weight. This could happen if the company takes on too much debt, neglects important aspects of its operations, or fails to adapt to changing market conditions. For example, a company might expand its operations beyond the carrying capacity of its workforce, which may result in low employee morale, burnout, and high turnover rates.

In **education**, overshoot could occur when a school or university admits more students beyond its carrying capacity. On one hand, this might lead to a temporary increase in enrollment and revenue. On the other hand, it could come at the expense of other important aspects of the quality of education, such as individualized and advanced learning. A school might accept more students than its classrooms can accommodate, which then results in overcrowded classrooms and a decline in student learning outcomes.

A school or university could experience a collapse if it becomes too reliant on a single source of funding beyond its carrying capacity. In fact, if the funding source fades, then the institution may be unable to continue operating at the same level. A university might heavily depend on the tuition revenue from international students. This circumstance may go beyond the university's carrying capacity, such as providing appropriate support and services to students, and result in a decline in enrollment if visa policies change.

In **healthcare**, overshoot could occur when a hospital or a healthcare system attempts to provide care beyond its carrying capacity by providing care to more patients than it can support. This might lead to a temporary increase in patient volumes and revenue, but may result in substantial deterioration of important aspects such as quality and safety. A hospital might admit more patients than the staff and resources can handle, which then results in longer waiting times, medical errors, and a decline in patient satisfaction.

A healthcare system could experience a collapse by overfocusing on cost-cutting measures to provide adequate care beyond its carrying capacity. As a consequence, patients may seek alternative care elsewhere if they perceive that the quality of care is declining. As a consequence, that leads to a decline in revenue and a further decline in the quality of care. A healthcare system might cut staff and resources beyond its carrying capacity to provide necessary care, which then results in a decline in patients' outcomes and reputation.

4.6.1 *Causal loop diagram*

Figure 4.18 reveals the **second step of the overshoot and collapse** pattern, in which the state of the system refers to the current condition of the system (Sterman, 2000).

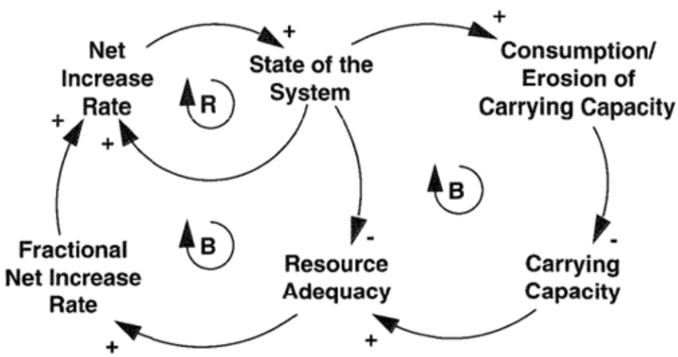


Figure 4.18. Overshoot & collapse: Causal loop.

Figure 4.18 presents the following variables and components. The **fractional net increase rate** (FNIR) is the relative rate at which the population (or resource use) grows and is expressed as a fraction. It is the difference between the birth rate (or resource acquisition rate) and the death rate (or resource depletion rate).

The **net increase rate** (NIR) is the absolute rate at which the population (or resource use) grows. It is calculated by multiplying the FNIR by the state of the system.

The **state of the system** (S) is the current population (or the level of resource use) in the system.

Resource adequacy (RA) is the availability of resources in the environment relative to the current population (or resource use) level. It is generally expressed as a ratio of the carrying capacity to the state of the system.

The **consumption erosion of carrying capacity** (CECC) is the decrease in carrying capacity due to overconsumption or overuse of resources. When resource use becomes unsustainable, the carrying capacity of the environment is reduced.

Carrying capacity (CC) is the maximum population (or resource use) level that the environment can sustainably support without degrading its ability to provide resources.

4.6.2 *Stocks and flows diagram*

In the context of the overshoot and collapse pattern, the stocks and flows diagram in Figure 4.19 represents an overshoot and collapse behavior by adjusting the variables to simulate changes in resource availability and pollution levels.

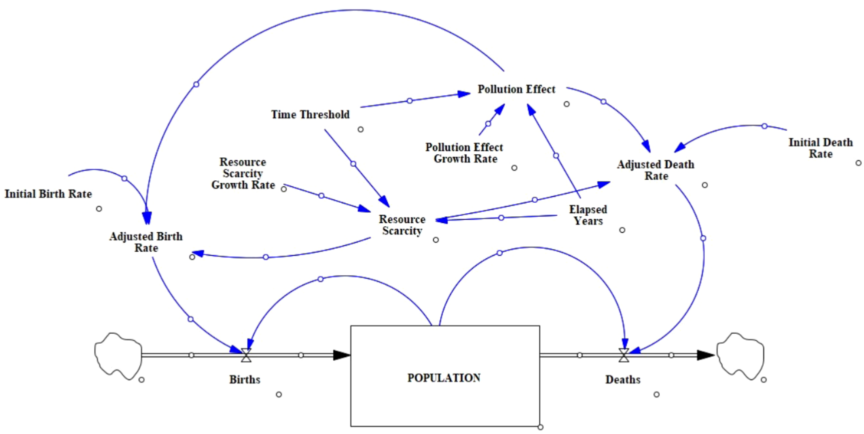


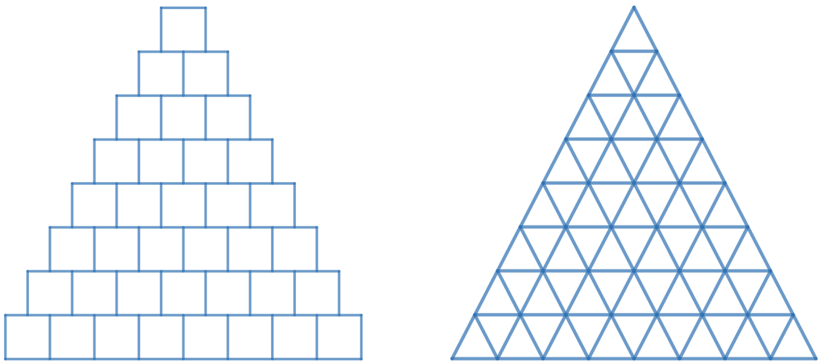
Figure 4.19. Overshoot & collapse: Stocks & flow diagram.

Observe that in Figure 4.19, Eq. (3.1) describes the difference between the birth and death rates. Also, note that increasing resource scarcity or the pollution effect will lead to a decline in birth rates and an increase in death rates, potentially causing the population to collapse.

More supplemental details about the overshoot and collapse pattern are elaborated upon in Section 9.5.6.

4.7 End of Chapter Summary

Analyzing and detecting various patterns with numerous observations trains and enhances our analytical, cognitive, and comparison skills. What are the unique characteristics of each pattern? What are the similarities and contrasts between different patterns? When and how do we apply a specific pattern? For instance, what are the similarities and differences between the pyramid-shaped structures sketched in the following two diagrams.



4.8 Further Thoughts

1. In Sections 4.1–4.6, we discussed the various patterns of behavior. Why do the reinforcing and balancing loops only emerge in goal-seeking and S-shaped growth patterns?
2. What patterns from Sections 4.1–4.6 can you apply to study weather patterns? In fact, what specific weather pattern can you match with a pattern from Sections 4.1–4.6?
3. What patterns from Sections 4.1–4.6 can you apply to study psychology behaviors? In fact, what specific psychological behavior can you match with a pattern from Sections 4.1–4.6?
4. In Section 4.3, the S-shaped growth with overshoot pattern was presented in Figure 4.8. Note that Figure 4.8 describes the S-shaped growth with an overshoot pattern as eventually oscillatory and transitions to the oscillation pattern outlined in Section 4.5 and in Figure 4.14. How do you determine the length of the transient time prior to the emergence of oscillatory behavior? In particular, what are the shortest and longest transition phases?

Chapter 5

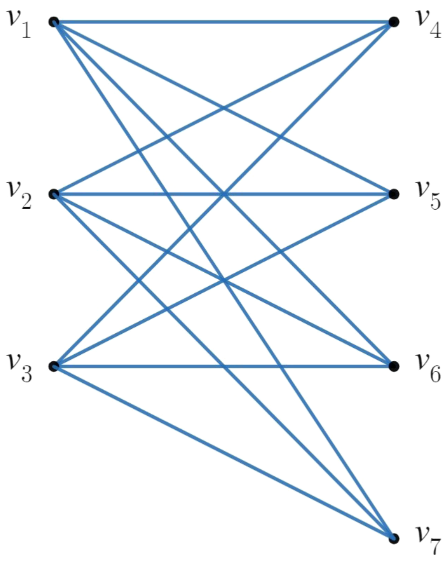
Hierarchical vs. Agent-Based Systems

In Section 2.3.3, we defined an **agent-based system** as a system that examines interactions among autonomous agents (individual and group entities) to accurately and precisely understand the behavior of a system and what factors regulate the outcomes. An agent-based system is a micro-scale model that describes the simultaneous interactions of numerous agents to accurately trace and predict the appearance of complex phenomena (Gustafsson and Sternad, 2010).

In fact, the new agent-based systems emphasize that "the whole is greater than the sum of its parts." The characteristics of the higher-level system often originate from the interactions among the lower-level subsystems. This implies that macro-scale state changes emerge from micro-scale agent behaviors. Furthermore, in agent-based systems, simple behaviors lead to complex behaviors, where state changes occur at the whole system level.

An agent-based system was first developed during the 1940s by John von Neumann while he was conducting research on cellular automata. In 1971, Thomas Schelling assembled an agent-based segregation model, which he presented in his paper, "Dynamic models of segregation." Schelling's agent-based models emphasized the interaction of autonomous agents in a shared environment with an observed cumulative and noticeable outcome (Schelling, 1971).

The following bipartite graph $K_{3,4}$ presents a possible scheme of a complex agent-based system with multiple connections between the components.



On the other hand, we defined a **hierarchical system** as a system that outlines a scheme of different ranks or positions, or administrative or managerial positions. Hierarchical systems are also structured, systematic chains of command with well-defined roles and responsibilities. Hierarchical systems are often used in organizations or institutions where a decision-making system exists. Hierarchical systems present a sketch of organizational communication among the ranks. Hierarchical systems are also assembled to provide a systematic scheme of decision-making responsibilities.

Hierarchical systems have numerous applications in robotic paradigms, computer-aided production engineering, real-time control systems (RCSs), real-time control system software, computer architecture, and artificial intelligence. The following tree outlines a potential structure of a hierarchical system.

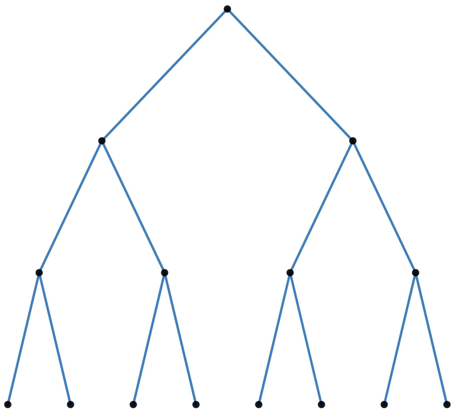


Figure 5.1 presents the rudiments of the hierarchical vs. agent-based cycle.

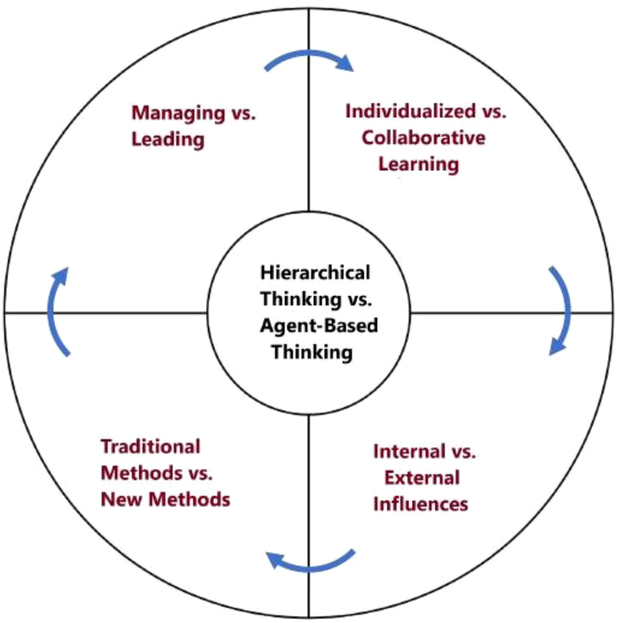


Figure 5.1. Hierarchical vs. agent-based cycle.

Observe that a hierarchical system focuses on deduction, while an agent-based system focuses on induction. A hierarchical system is more oriented toward internal factors, while an agent-based system is more oriented toward external factors. Figure 5.2 presents a Venn diagram of hierarchical versus agent-based systems.

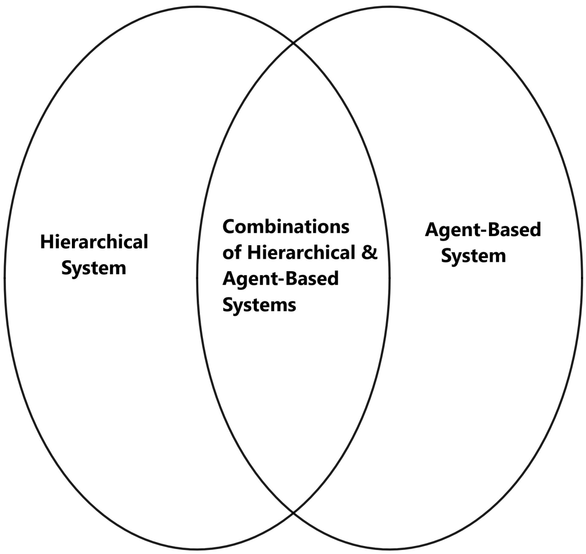


Figure 5.2. Venn diagram model of hierarchical vs. agent-based systems.

How do you transition from one system to another? What traits can you recycle and reuse, and what new tactics will emerge during the transition? How do specific roles change while transforming from one system to the next? What new problems and challenges arise during and after the transition?

5.1 Systematic Design

Which system do we choose while attempting to design an organizational system: a hierarchical system, an agent-based system, or a combination of the two systems? This will depend on the organization's orientations and short- and long-term aimed outcomes. What are the advantages and disadvantages of the two systems? Which system provides better training and guidance? Which system will navigate to better outcomes? Which system provides a more amiable working environment? Which system is more globally oriented? Sections 5.1.1 and 5.1.2 will thoroughly examine these questions.

5.1.1 *Centralized management system*

Centralized guided management in hierarchical systems refers to the concentration of decision-making authority at the top administrative levels. These include the president, or the CEO of a corporation, or the provost, president, and board of trustees in a university. This approach simplifies communication channels and enables organizations to maintain consistency in policies and procedures. However, it can also lead to reduced adaptability and slower response times to changing environments. Centralized control has been extensively studied in various fields, such as business management (Chandler, 1962; Mintzberg, 1979), computer science (Bertsekas and Tsitsiklis, 1997), and sociology (Weber, 1947). Researchers discovered that, on the one hand, centralized control can provide stability and efficiency in some contexts, and on the other hand, it can hinder creativity, innovation, and employee empowerment in others (Daft, 2015; Williamson, 1981). Figure 5.3 illustrates the following recommended scheme of decision-making in hierarchical systems:

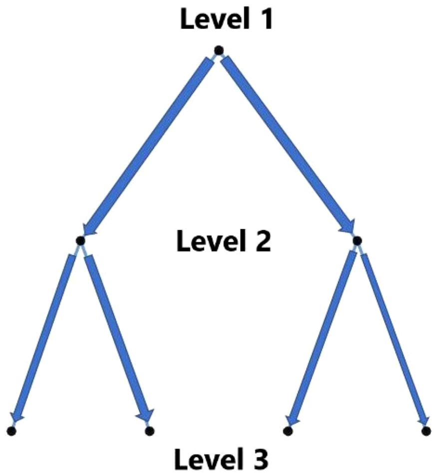


Figure 5.3. Recommended decision-making scheme in hierarchical systems.

Figure 5.3 reveals the following attributes:

Command is the first attribute. It is represented by a centralized administration, where the decision-making power is concentrated at the top levels of the organization (Levels 1 and 2 in Figure 5.3) (Mintzberg, 1979).
Communication is the second attribute. Observe that information flows vertically from Level 1 to Level 2 and from Level 2 to Level 3, as shown in Figure 5.3, with directives moving down from the top and feedback moving up from lower levels (Daft, 2015).
Standardization is a notable attribute in hierarchical systems. In this case, the centralized administration presented in Level 1 in Figure 5.3 enforces uniformity in policies, procedures, and goals across the organization (Chandler, 1962).

Figure 5.3 also unfolds the following implications:

Consistency is the first important implication. Organizations with centralized administration can maintain a unified strategic approach, which leads to implementation (Mintzberg, 1979).

Monitoring is another vital implication. The upper management can closely monitor the performance and resource allocation of the lower-level units, as shown in Figure 5.3 (Williamson, 1981).

Reduced adaptability is a very notable implication, as the centralized management can impede the ability of an organization to quickly adapt to changing circumstances or local needs (Bertsekas and Tsitsiklis, 1997).

However, the centralized management in hierarchical systems presents the following obstacles, limitations, and challenges:

Creativity is the first potential obstacle as a result of centralized management. In fact, by discouraging input from lower-level employees, centralized management could potentially limit innovation opportunities for its employees (Weber, 1947).

Slow responsiveness is another potential obstacle. In fact, the centralized management could experience potential delays in decision-making due to limited access to information and the approval from higher-level managers (Daft, 2015).

Employee motivation could also result as a consequence of centralized management. In particular, centralized management can undermine employees' motivation and job satisfaction by limiting autonomy and participation in decision-making (Williamson, 1981).

Bureaucracy could be a menacing consequence of centralized management. Bureaucracy can result in delayed adaptation and decision-making and hence in reduced employee autonomy (Weber, 1947).

The centralized management in hierarchical systems also presents additional obstacles, limitations, and gaps that result in quality deterioration:

Evaluating **employee satisfaction** can help gauge the impact of centralized management on employees. Factors such as job satisfaction, a stimulating working environment, and empowerment can be assessed through employee surveys and interviews (Daft, 2015).

Centralized management can have a significant impact on the **organizational culture**. This has a strong influence on important aspects such as communication, innovation, and collaboration. Assessing the overall culture can be achieved through a combination of interviews, observations, and surveys (Schein, 2010).

Centralized management strongly affects the organization's **flexibility and adaptability**, which are essential factors that lead to achieving its long-term goals. Assessing an organization's ability to adjust to changes in the market or external environment can provide insights into the effectiveness of centralized management. This can be done through case studies, historical analyses, and expert opinions (Mintzberg, 1979).

5.1.2 *Open management system*

The decentralized open-ended agent-based systems can be described as more democratic in comparison to the centralized guided management hierarchical systems. First, agent-based systems offer more flexibility and diversity and are more globally oriented to achieve more diverse and complex tasks. Second, agent-based systems are more focused on innovations and individualized learning; therefore, they require strong leadership qualities, such as self-discipline, self-leadership, and time management skills. Figure 5.4 illustrates the following recommended agent-based scheme.

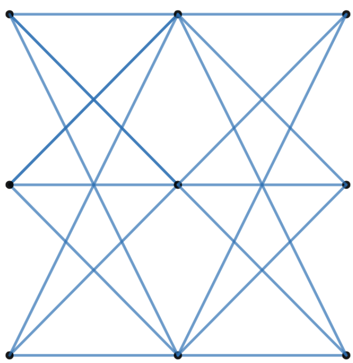


Figure 5.4. Recommended agent-based scheme.

Figure 5.4 presents the following attributes:

Autonomy is an important attribute, as agents operate independently and can make their own decisions based on local information without centralized control or global knowledge (Bonabeau, 2002).
Local interactions among the agents are the next important attribute. In particular, instead of relying on a central authority in decentralized systems to communicate. As shown in Figure 5.4, local interactions lead to more flexible and efficient communication and interaction for each agent with the neighbors or nearby agents (Wooldridge, 2009).
Scalability is another notable attribute in a decentralized system. Decentralized systems are easier to scale, as adding or removing agents has minimal impact on the overall system (Parunak, 1997). In fact, it is easier to scale the agent-based system in Figure 5.4 in comparison to the hierarchical system in Figure 5.3.
Emergent behavior is also a contributing attribute of a decentralized system. In fact, complex global behavior can emerge from the simple and local interactions of individual agents (Bonabeau, 2002).
Adaptability is an essential virtue due to external and international influences. In particular, agents in decentralized systems can adapt their behavior based on local circumstances and interactions, allowing for greater flexibility and responsiveness (Parunak, 1997).
Robustness is a vital feature, as decentralized systems are more resilient to individual agent failures. In fact, an individualized failure of a specific agent in Figure 5.4 does not result in a single point of failure, as presented in Figure 5.3 (Bonabeau, 2002).

Figure 5.4 also reveals the following challenges:

Enhanced fault tolerance is the first problem that originates in the agent-based system. In fact, the decentralized control makes the system more resilient to failures, as there is no single point of failure (Wooldridge, 2009). Due to multiple connections between the agents, one failure could cause a domino effect with numerous failures, as can be seen in Figure 5.4.

Increased complexity is another challenge that is often encountered in agent-based systems. In particular, decentralized control can lead to more complex and unpredictable system behavior and hence can result in a more challenging analysis and management (Parunak, 1997). Complexity increases as the number of agents and connections increases.

Agent-based systems can encounter **limited coordination** as a challenge, as shown in Figure 5.4. Achieving global coordination and synchronization can be more challenging in decentralized systems due to a lack of central control (Bonabeau, 2002). Limited coordination can occur due to a lack of self-discipline, time management skills, and experience.

Network topology examines the structure of agent connections and interactions that can influence the system's overall behavior and performance (Parunak, 1997).

5.1.3 *Management systems: Stocks and flows diagram*

In Sections 5.1.1 and 5.1.2, we examined the similarities and contrasts between centralized and open management systems. How do we transition from one system to the next? We will apply the stocks and flows diagrams developed in Section 3.2.2 together with Eq. (3.1) to address this question. Stocks and flows are the fundamental ingredients of system dynamics models. Jay Forrester referred to stocks as levels and to flows as rates. A stock accumulates over time through inflows and dissipates over time through outflows. A flow influences a stock over time. In fact, the stock increases with respect to inflows and diminishes with respect to outflows.

Figure 5.5 represents the dynamics of a system with agents joining and leaving the centralized decision-making structure based on various factors, such as financial incentives, regulatory environment, trust level in the central agent, and autonomy preference.

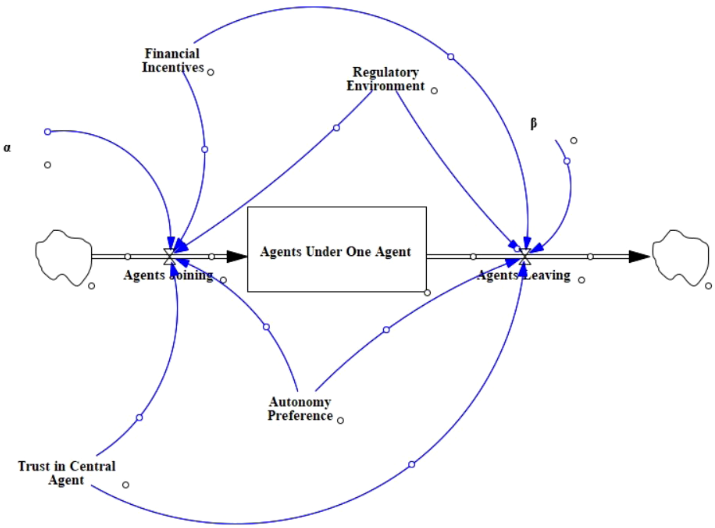


Figure 5.5. Centralized management system: stocks & flows diagram.

The stock represents the centralization in the system, while the flows (A_0 and A_1) and the variables (α, β, F_i, R_e, T_a^c, and A_p) help describe the factors influencing the agents' decisions to either join or leave the centralized system. First, note that Figure 5.5 presents the following flows:

A_0 presents the **rate of agents joining**. This is the process of agents joining into a single centralized agent (unit: agents/time).
A_1 resembles the **rate of agents leaving**. This is the process of decentralizing, that is, agents leaving the centralized agent (unit: agents/time).

Next, observe that Figure 5.5 portrays the following variables:

α is the **joining rate coefficient**, or the entry rate coefficient. This variable represents the proportionality factor that influences the rate at which agents join or enter the centralized system. It determines how sensitive the joining process is to the effects of financial incentives, the regulatory environment, trust in the central agent, and autonomy preference. The unit of this variable is measured as the number of agents joining per month.

β is the **leaving rate coefficient**, or the exit rate coefficient. This variable represents the proportionality factor that influences the rate at which agents leave or exit the centralized system. It determines how sensitive the leaving process is to the effects of financial incentives, the regulatory environment, trust in the central agent, and autonomy preference. The unit of this variable is measured as the number of agents leaving per month.

F_i represents the **financial incentives**. This dimensionless variable represents the monetary benefits offered by the central agent to attract agents to join or remain under their control. Higher financial incentives may lead to more agents joining and fewer agents leaving the centralized system.

R_e represents the **regulatory environment**. This dimensionless variable describes the presence of laws or regulations that either encourage or discourage centralization. A favorable regulatory environment for centralization might increase the rate of agents joining and decrease the rate of agents leaving the centralized system.

T_a^c is the **trust level of the central agent**. This dimensionless variable reveals the trust level in the central agent's ability to manage and govern the system effectively. Higher trust levels can increase the rate of agents joining and decrease the rate of agents leaving the centralized system.

A_p is the **autonomy preference**. This dimensionless variable outlines the preference of agents for maintaining autonomy and independence during the decision-making process. A strong preference for autonomy may result in a higher rate of agents leaving and a lower rate of agents joining the centralized system.

5.2 Concrete vs. Abstract Representation

Concrete vs. abstract representation examines the contrasts between individualized and collaborative learning, direct route and indirect route with many turns, graphical and analytic representations, standard and non-standard methods, provided resources and alternative resources, mechanical work and creative work, easy and hard choices, few choices and several choices, theoretical and experiential learning, traditional teaching and learning and online teaching and learning, synchronous and asynchronous online environments, parallel and series wiring, etc. Figure 5.6 determines the total number of equilateral triangles at the same scale through an arrangement into rows with an odd number of triangles in each row, starting with one triangle in the first row, three triangles in the second row, etc.

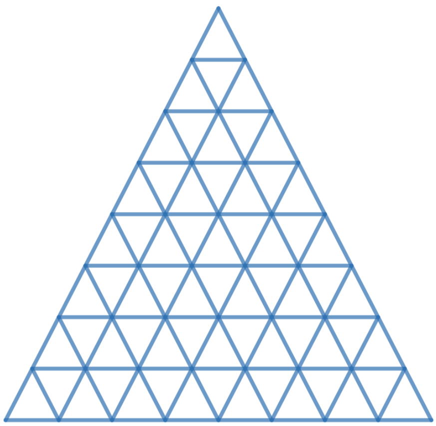


Figure 5.6. Pyramid-shaped system of triangles.

Then, for all $n \in \mathbb{N}$, the number of triangles in Figure 5.6 is characterized by the corresponding **linear summation**:

$$1 + 3 + 5 + 7 + 9 + 11 + \cdots + (2n-1) = \sum_{i=1}^{n} (2i-1) = n^2. \quad (5.1)$$

Note that Figure 5.6 is the geometrical or graphical representation of Eq. (5.1), which adds consecutive positive odd integers starting with 1 and adds up to a perfect square.

Concrete vs. abstract representation also addresses the following questions: How much guidance is provided? How far is it past your comfort zone? How far do you expand and think beyond your comfort zone? Figure 5.7 unfolds the answers to these questions.

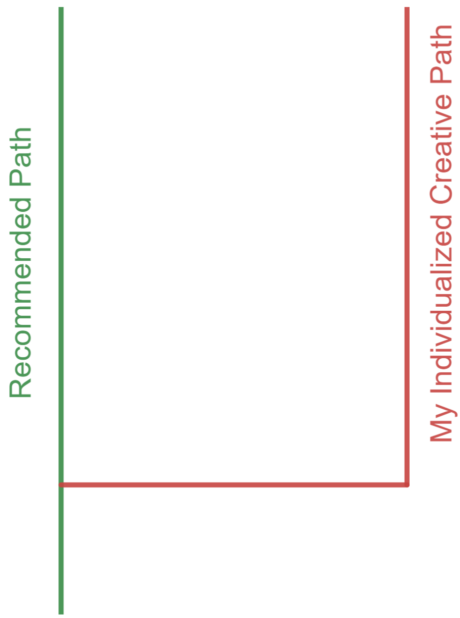


Figure 5.7. Recommended path vs. individualized path.

Figure 5.7 also analyzes when to follow the recommended colleagues' and supervisors' paths and when to design your own individualized creative learning path. Do the hierarchical systems orient you toward a guided green path, and do the agent-based systems direct you to discover your own red path? Sections 5.2.1 and 5.2.2 address the answers to these questions.

5.2.1 *Concrete representations*

Concrete representations in hierarchical systems are an approach that aims to improve the understanding and modeling of complex systems using tangible and explicit models that depict the fundamental elements and relationships within a system. Concrete representations address questions that have either one or a few right answers.

The aims of concrete representations are to make challenging concepts accessible and easier to recognize by applying strategies such as metaphors, maps, graphs, tables, and charts, emphasizing unique characteristics and details, decomposition into different categories, decomposition into different colors, and decomposition into different patterns.

Concrete representation emphasizes the essence of experiential learning, analysis, and deductive reasoning and directs you to the green guided path in Figure 5.7. It also aims to illustrate concepts as clear as possible that are straightforward to grasp and retain. These concepts have very few gaps or missing details and are often a direct or very similar analog of a different concept with minor differences. In Discrete Mathematics, to determine the **Cartesian product** of the associated sets

$$\begin{aligned} A &= \{\mathrm{a},\ \mathrm{b}\}, \\ B &= \{\alpha,\ \beta,\ \gamma\}, \end{aligned}$$

we match each English letter **a** and **b** with each Greek letter α, β and γ and acquire the corresponding analytical formulation of the **Cartesian product**:

$$\begin{aligned} &\{\mathrm{a}, \alpha\},\ \{\mathrm{a}, \beta\},\ \{\mathrm{a}, \gamma\} \\ &\{\mathrm{b}, \alpha\},\ \{\mathrm{b}, \beta\},\ \{\mathrm{b}, \gamma\}. \end{aligned} \tag{5.2}$$

We then describe Eq. (5.2) graphically as the related **Bi-partite graph** $K_{2,3}$:

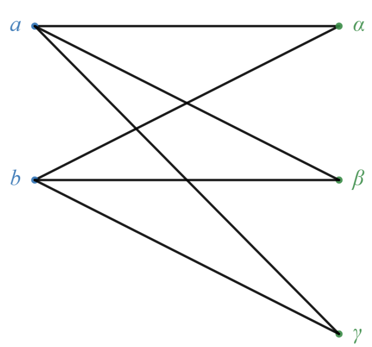


Figure 5.8. Cartesian product rendered as a bi-partite graph $K_{2,3}$.

Note that in Figure 5.8, the blue vertices **a** and **b** have three edges each, or **degree 3**, while the green vertices α, β, and γ have two edges each, or **degree 2**.

In linguistics, concrete words reveal a hierarchical semantic structure. This structure depends on the coordinate and superordinate categorical interrelationships. In the meantime, abstract representations are assembled as an associative architecture with connections between frequently used words.

In psychology, in comparison to abstract concepts, numerous behavioral experiments show that by using lexical decisions, recognition, word naming, and other behavioral tasks, concrete concepts are retained longer (Schwanenflugel *et al.*, 1992), much easier to detect, much faster to read and comprehend, and much easier to learn. Similar results were encountered with the processing of concrete and abstract verbs (Alyahya *et al.*, 2018) and definitions (Borghi and Zarcone, 2016). This advantage of concrete semantics in comparison to abstract semantics is referred to as the "concreteness effect."

Concrete representations reveal the following attributes:

They are **detail-oriented**, as they outline a detailed view of the components and interrelationships within the hierarchical systems. They aim to provide clarity in studying and understanding complex structures (Johnson and Brown, 2017).

They are **experientially learning-oriented**. In fact, they aim to apply the base of knowledge to various fields to gain a more accurate and precise grasp of complex systems in different domains.

They **bridge theory and practice** as they pave a guided path between abstract theoretical models and real-world applications. How and when do you apply certain models, which focus on more accurate and precise testing and validation of developed theories.

Concrete representation has the following implications:

- They **enhance the decision-making process**. In particular, they provide a more accurate and precise understanding and management of complex systems, which can lead to better and more efficient decision-making in fields such as policy development, resource allocation, and system optimization (Jones, 2021).
- They lead to **methodological advancements**. In particular, the development and revision of concrete representations can guide one to methodological advancements in the study and modeling of hierarchical systems, potentially revealing new research-oriented and innovative avenues.
- They stimulate **interdisciplinary collaborations**. The versatility and applicability of concrete representations across different domains can promote interdisciplinary collaboration, as researchers from various disciplines, experiences, and backgrounds can benefit from the two-directional exchange of ideas (Chen and Huang, 2020).

5.2.2 *Abstract thinking*

In comparison to concrete representations in hierarchical systems in Section 5.2.1, abstract thinking in agent-based systems focuses on open-ended questions with multiple answers, no right answers, or perhaps no answers at all and directs you to the non-guided red path in Figure 5.7. In linguistics, how do you interpret words and expressions such as good education, risk, comfort zone, accomplishment, long journey, beautiful scenery, and fast response? The answers to these questions will depend on an individual's educational background, experiences, goals, and orientations. Abstract thinking also presents concepts with missing gaps and fragments, concepts with multiple comparisons, and connections and concepts with multitasking steps. You can encounter the rudiments of abstract thinking in STEM disciplines, economics, humanities, and the arts. The photograph in Figure 5.9 describes the mystical

Caribbean marinescape together with the fundamentals of abstract thinking.

Figure 5.9. Abstract thinking and the mystic Caribbean marinescape.

The marinescape in Figure 5.9 unfolds the following questions that will not have unique answers: Why do the clouds trace the island's peripherals and sketch the island's reflection? What are the island's pearls hidden beneath the mystic cloud?

In comparison to concrete representations, concepts that relate to abstract thinking take longer to process, grasp, and retain. In addition, abstract-related concepts often require numerous repetitions before they start to sink in. Abstract thinking also lacks specific subject orientations and goals and hence can initially emerge as ambiguous and nebulous. This occurs due to multiple connections, comparisons, and numerous comprehensions.

Abstract thinking presents the following attributes:

It focuses on **generalization** as it enables agents to inductively generalize from a specific instance and apply the developed base of knowledge to new situations while increasing their adaptability.

It directs agents to thoroughly **decipher and reason** complex problems and relationships within the system and hence make more accurate decisions (Brown and Lee, 2020).

It aims to **simplify** complex systems by identifying high-level patterns and reducing computational demands.

Abstract thinking also presents the following implications:

It aims to **improve decision-making**. Agents with abstract thinking capabilities can make more accurate decisions in complex environments, which then leads to more effective resource allocation and system optimization.

It trains agents to **adapt faster** to changing environments while designing more flexible, robust, and resilient agent-based systems.

How do we link abstract thinking and concrete thinking? How do we transition from one to the other? Which transition is easier? Can we apply both tactics simultaneously?

5.3 Convergent vs. Divergent Thinking

Joy Paul Guilford (1897–1987) was an American psychologist who oriented his research on human intelligence and established the definitions of and distinction between convergent and divergent thinking. Guilford and his colleagues defined **divergent thinking** as the ability to generate multiple alternative solutions to a specific circumstance or problem. In fact, **convergent thinking** is deductively-oriented and aims to determine a unique well-defined solution to a problem. In the meantime, divergent thinking is inductively-oriented and aims to consider a spectrum of creative solutions.

Convergent vs. divergent thinking explores the disparities between one-dimensional and multi-dimensional thoughts, a unique solution and a spectrum of solutions, a unique answer and many answers, black & white and a multi-color spectrum, one interpretation and a range of interpretations, one route and multiple routes, etc. When and how do you use either convergent thinking, divergent thinking, or combinations? That will strongly depend on the aimed tasks and the complexity of the problems you are attempting to solve. It also depends on how quickly you need to respond to and resolve a specific problem.

For instance, to get from point A to point B, do you program the navigation system to choose the shortest distance, fastest time, most use of highways, etc.? If you have three options, A, B, or C to choose from, which is the best one? Figure 5.10 addresses these questions and unfolds the fundamentals of the convergent–divergent thinking cycle.

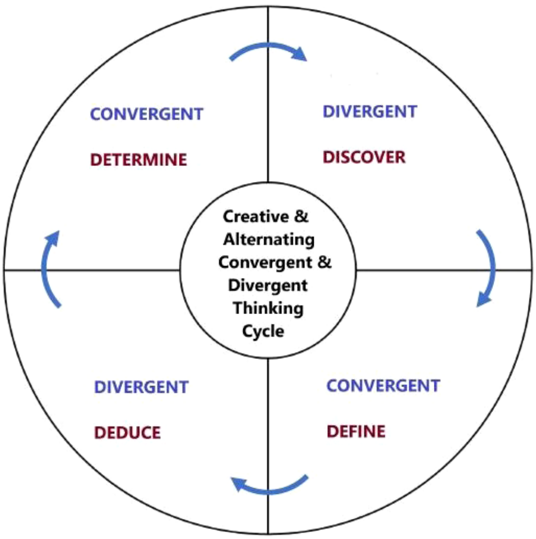


Figure 5.10. The convergent-divergent thinking cycle.

5.3.1 *Convergent thinking*

The **convergent thinking** technique focuses on finding or determining a unique and justified solution to a problem or an answer to a question. Also to obtain the correct, best, and the most efficient solution or answer. Convergent thinking highlights speed, accuracy, and logic and focuses on recognizing the familiar, reapplying techniques, and accumulating stored information. It is most effective in situations where an answer readily exists and requires modification or revision during the decision-making process. An essential characteristic of convergent thinking is that it navigates to a clear, unique, and best solution or answer (either right or wrong) and aims to reduce or eliminate ambiguity (Cropley, 2006). Convergent thinking directs you to the green-guided path in Figure 5.7. Figure 5.11 focuses on these factors and presents the following characteristics of convergent thinking.

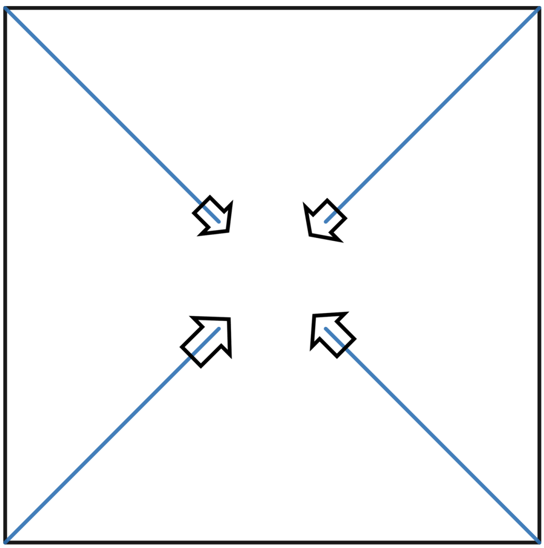


Figure 5.11. Characteristics of convergent thinking.

In Figure 5.11, convergent thinking refers to the base of developed knowledge while attempting to determine the best solution or the best answer. In fact, the basis of known knowledge is a vital aspect of creativity, as it is a source of ideas that sketches the recommended pathways to finding answers and solutions and outlines the criteria of effectiveness and novelty (Cropley, 2006).

The American Scholastic Aptitude Test (SAT) is a multiple-choice-oriented exam where each question has five answers. Students are trained to apply convergent thinking to either solve directly, use the process of elimination, or work answers backward by substituting. Students are also trained to solve problems correctly and efficiently, as questions must be solved within the assigned time limit. Convergent thinking also trains students to recognize or detect specific characteristics and then apply deductive reasoning to make accurate conclusions. The following is a sample mathematics question:

If 18 is 15% of 30% of a certain number, what is the number?

A. 9
B. 36
C. 40
D. 81
E. 400

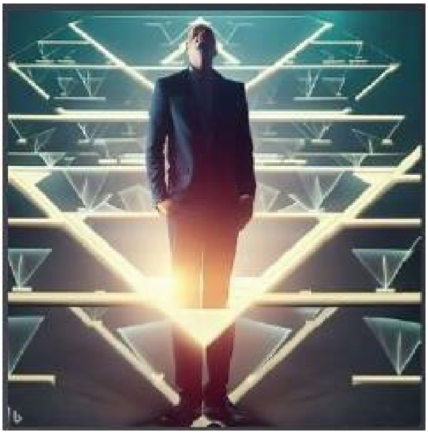
Convergent thinking in hierarchical systems is characterized by several attributes that influence the performance and decision-making processes within these structures (Cropley, 2006). The key attributes include problem-solving, focusing on a unique and best solution and answer, and adherence to established rules and procedures (Guilford, 1950). On one hand, convergent thinking can lead to efficient decision-making. On the other hand, convergent thinking may limit creativity and inhibit the exploration of alternative thinking, solutions, and ideas (Runco and Mraz, 1992).

The implications of convergent thinking in hierarchical systems are orientations toward enhancing consistency, stability, and predictability (Adair, 2010). However, this approach may lead to rigidity and resistance to change, which then results in challenges for organizations to effectively adapt in dynamic environments (O'Connor, 1998).

Organizational culture, leadership styles, communication patterns, and the level of complexity of tasks are the primary factors influencing convergent thinking in hierarchical systems (Lubart, 2001). In fact, highly structured and bureaucratic organizations tend to foster convergent thinking, while more flexible and adaptive systems encourage divergent thinking (Amabile, 1996).

The limitations and gaps associated with convergent thinking in hierarchical systems arise from the inherent nature of this cognitive process (Paulus and Nijstad, 2003). First, convergent thinking may overlook innovative or unconventional ideas that could lead to better outcomes as the method focuses on finding a unique and best solution or answer (Csikszentmihalyi, 1996). Second, convergent thinking may result in a monotone working environment where dissenting opinions are discouraged, which can hinder open communication and stifle creativity (Nemeth, 1997).

To reduce the limitations and fill in the gaps, organizations should aim to achieve a balance between convergent and divergent thinking, encouraging open-mindedness, and respecting and valuing diverse perspectives (Sternberg, 2003). Implementing collaborative decision-making processes, promoting continuous learning, and fostering a culture of innovation can help mitigate the drawbacks of convergent thinking in hierarchical systems and unlock their full potential (Nonaka and Takeuchi, 1995). The corresponding image is created by AI, displays the convergent thinking process.

On the one hand, convergent thinking focuses on a specific orientation and aims to accomplish a concrete goal. On the other hand, it can result in incorrect conclusions and may also lead to a loss of alternatives that can welcome new opportunities and horizons of innovative ideas and potential.

5.3.2 *Divergent thinking*

In contrast to convergent thinking, the **divergent thinking** technique aims to discover the diversity of solutions to a problem or answers to a question. Divergent thinking directs you to the red non-guided path in Figure 5.7 and strives to obtain creative solutions or answers. In some instances, solutions or answers may be similar, while in other circumstances, sharp contrasts can emerge among them. Divergent thinking emphasizes curiosity, brainstorming and mind mapping, explorations outside your comfort zone, comparative skills, innovative thinking, and risk-taking. Divergent thinking has been widely studied in human cognition (Guilford, 1950) and is considered to play an essential role in creativity, innovation, leadership, and emotional intelligence.

Recently, researchers have explored the potential of implementing divergent thinking in agent-based systems. These systems consist of autonomous, interacting agents that can be used to model complex adaptive systems, offering a useful framework for examining the impact of divergent thinking on problem-solving and adaptation. Figure 5.12 focuses on these factors and presents the following characteristics of divergent thinking.

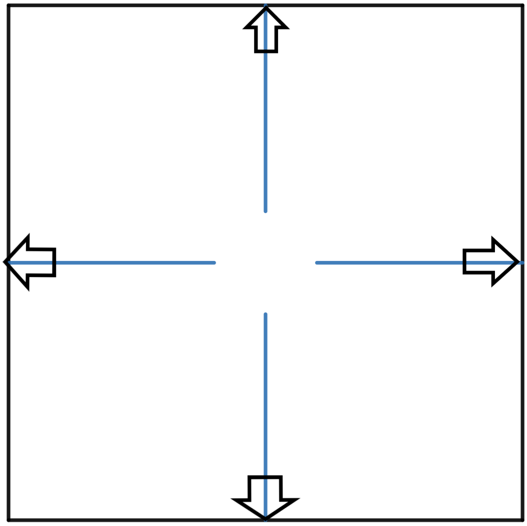


Figure 5.12. Characteristics of divergent thinking.

Figure 5.12 presents the following attributes of divergent thinking in agent-based systems.

In agent-based systems, divergent thinking stimulates agents to **develop many new innovative ideas** (Cropley, 2006). This can be achieved by applying different algorithms, such as genetic algorithms, particle swarm optimization, reinforcement learning, and thinking beyond your comfort zone by detecting mistakes and missing fragments.

The **novelty of generated ideas** is a critical aspect of divergent thinking. In agent-based systems, agents should be able to produce new and original solutions, which can be assessed using novelty metrics (Lehman and Stanley, 2011).

Divergent thinking also emphasizes **flexibility** in exploring different problem domains or solution spaces. In agent-based systems, this can be represented by agents that can adapt and modify their strategies in response to changing environments or new information (Mitchell, 2009).

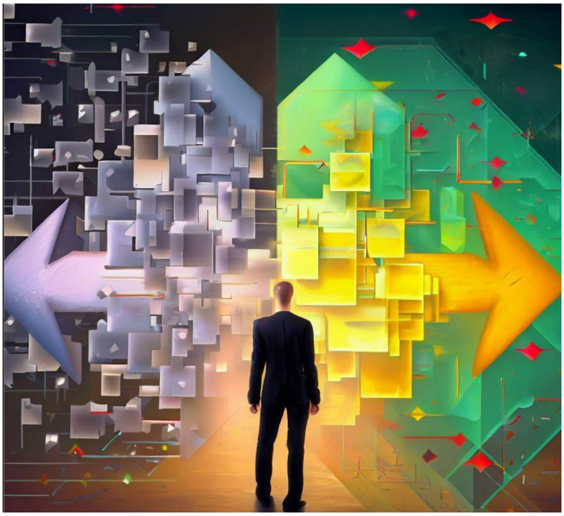
Figure 5.12 presents the following factors that affect divergent thinking in agent-based systems:

The **architecture of the agents** in agent-based systems can influence their ability to exhibit divergent thinking. For instance, agents with more complex internal models and decision-making processes are more likely to characterize divergent thinking (Epstein and Axtell, 1996).

Interaction mechanisms among the agents in agent-based systems and their environment can also impact the emergence of divergent thinking. Stronger interaction mechanisms can lead to more diverse outcomes (Miller and Page, 2007).

Agent-based systems are more sensitive to **initial conditions** or initial inputs in comparison to hierarchical systems. The initial conditions, such as agent distribution, resources, and parameters, can influence the development and enhancement of divergent thinking in ABS.

The corresponding image is created by AI, portrays the divergent thinking process.



On one hand, divergent thinking assumes numerous possibilities and hence stimulates alternative and creative thinking. On the other hand, the diversity of possibilities can be really confusing and can impede or even halt the decision-making abilities and prevent achieving the desired aims.

5.4 Learning and Influencing Factors

Learning is the process of obtaining new orientations, knowledge, skills, values, attitudes, and preferences. Learning is a lifelong process and can be decomposed into numerous categories, such as individualized learning, collaborative learning, experiential learning, cross-disciplinary learning, and cross-cultural learning. Learning strengthens our experiences and intuitions and expands our comfort zones and horizons. Some of the learning experiences can be spontaneous and immediate, induced by a single event. However, a large portion of learning experiences are gradually obtained through multiple repetitions (Lakoff and Johnson, 2008).

Influencing factors can significantly contribute to the learning process. First, influencing factors provide instrumental feedback and recommendations that promote alternative and creative thinking and unfold new horizons of opportunities. Second, influencing factors stimulate a two-directional exchange of ideas. In particular, colleagues with different educational and experiential backgrounds can introduce new ideas and practices, which can guide you to alternative ideas and new orientations. Sections 5.4.1 and 5.4.2 will elaborate on internal and external influences.

5.4.1 *Continuous learning*

Continuous learning is oriented toward perpetually obtaining new knowledge and skills. It emphasizes revisions, fresh iterations, progression, new enhancements, growth, incremental changes, and efficiency. Continuous learning is a vital aspect of modern organizational management. It presents opportunities for employees and staff to adapt and grow in response to rapidly changing environments. Hierarchical systems, characterized by a top-down structure with clearly defined roles and responsibilities, can benefit significantly from integrating continuous learning practices. Figure 5.13 presents the three primary forms of continuous learning.

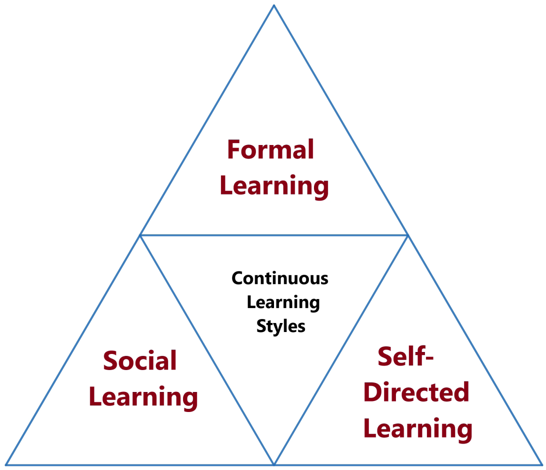


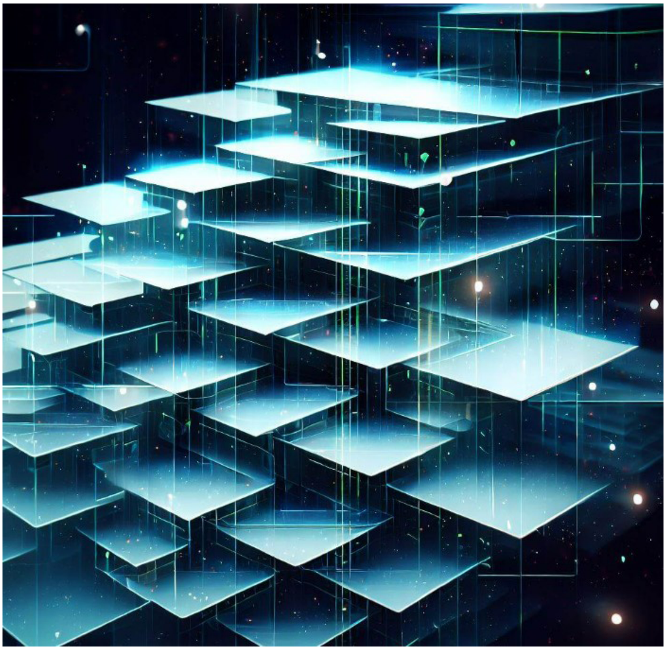
Figure 5.13. Three primary forms of continuous learning.

Formal learning is individualized-learning oriented. It includes taking university-level courses, e-learning courses, mobile learning courses, and MOOCs. In addition, formal learning includes participation in conferences, external workshops, and internal training programs within the organization.

Social learning is collaborative- and experiential-learning oriented. It involves discussion and collaboration on social media, finding blogs and additional resources to gain a stronger grasp, working and communicating with coworkers, coaching and mentoring, and learning and gaining experiences while working (on-the-job training).

Self-directed learning is individualized- and experiential-learning oriented. Examples of self-directed learning can include researching and reading to get further acquainted with a theme, listening to related podcasts, watching related instructional videos, and experimentation and exploration.

The corresponding image is created by AI, portrays the continuing learning process.



The development of feedback loops is one of the primary advantages of continuous learning in hierarchical systems. In fact, feedback loops lead to interconnected processes and self-organizing structures that foster ongoing development and improvement at all levels of an organization (Argote, 2013; Senge, 2006). This includes the design of systematic schemes and mechanisms for employees to access learning opportunities, provide training and development programs, and promote knowledge-sharing and collaboration among the team members. By investing in continuous learning, organizations can enhance their system's adaptability, resilience, and responsiveness to emerging challenges and opportunities.

On the other hand, the potential resistance to change from employees or leaders who may be accustomed to traditional management approaches is one of the primary limitations and disadvantages of continuous learning in hierarchical systems (Bresman and Zellmer-Bruhn, 2013). Furthermore, implementing continuous learning initiatives can require significant resources, such as an additional budget for tuition and additional release time to take courses and participate in seminars, workshops, and conferences. These supplemental resources may be challenging for organizations to obtain due to limited budgets and limited staff and personnel. Further research is necessary to better understand how to overcome these challenges and optimize continuous learning in hierarchical systems from a systems theory perspective.

5.4.2 *Emergent learning*

Emergent learning, in agent-based systems, highlights the essence of "learning from experience." Emergent learning relates to experiential learning by conducting intentional and iterative learning experiments numerous times. Emergent learning is also associated with breakthroughs, disruptions, paradigm-shifting results, raw novelty, and market creations. This strategy often leads to learning simultaneously and to new and powerful outcomes and masteries. Emergent learning is an approach that focuses not only on producing the best outcomes but also on swift adaptations during challenging circumstances in order to achieve the best outcomes.

Emergent learning in agent-based systems also aims to adapt and describe the complex patterns and behaviors that emerge from the interactions of simpler components or agents within a system. Individual agents have limited knowledge and capabilities. However, the interactions among the components give rise to more sophisticated and intelligent behaviors. This phenomenon is often encountered in the fields of artificial intelligence, multi-agent systems, and swarm intelligence. Figure 5.14 presents the rudiments of the emergent learning process and cycle.

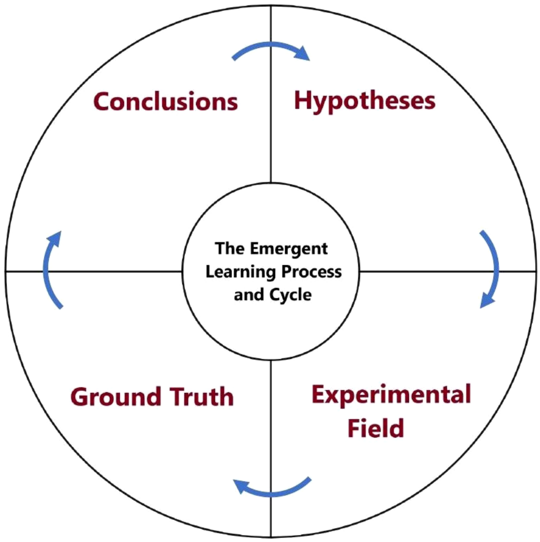


Figure 5.14. The Emergent learning process & cycle.

Hypotheses represent the first step of the cycle. Hypotheses assemble the base of the model by determining the right questions to ask. The base of questions initiates the development of the model, which leads to discovering the best solution to a specific assigned task.

Experimental field is the next phase of the cycle. This phase of the cycle carefully examines which experiments or trials to perform and how many times. These numerously repeated experiments then lead to new orientations.

Ground truth is the subsequent stage of the cycle. In fact, this stage of the cycle compares the results of the recent and past experiments. Ground truth also focuses on what revisions are necessary for improvements in future experiments.

Conclusions represent the final state of the cycle. In particular, conclusions analyze what happened and why. This final state of the cycle examines how successful the experiment was, what revisions to implement, and how many more times the process and the cycle are to be repeated.

The corresponding image is created by AI, portrays the emergent learning process.

Figure 5.14 revels the following implications of emergent learning:

Emergent learning **enhances problem-solving techniques** as agent-based systems aim to handle, manage, and monitor challenging complex problems that traditional and centralized approaches may not have the resources to handle or sustain (Bonabeau, 2002).

Experiential learning and hands-on learning are naturally encountered as emergent learning aims to study and handle real-world problems, such as traffic control, crowd simulation, and swarm robotics (Brambilla *et al.*, 2013).

On the other hand, emergent learning can lead to the following limitations and disadvantages:

- Emergent learning can sometimes result in unexpected and undesirable outcomes due to the complex and nonlinear interactions between agents.
- At times, it can be quite challenging to accurately orient emergent learning toward achieving specific goals, as the process is inherently decentralized.
- Large-scale agent-based systems with emergent learning may encounter computational complexity. This may require significant computational resources, which results in implementation challenges in practice.

5.5 Soft Tools vs. Hard Tools

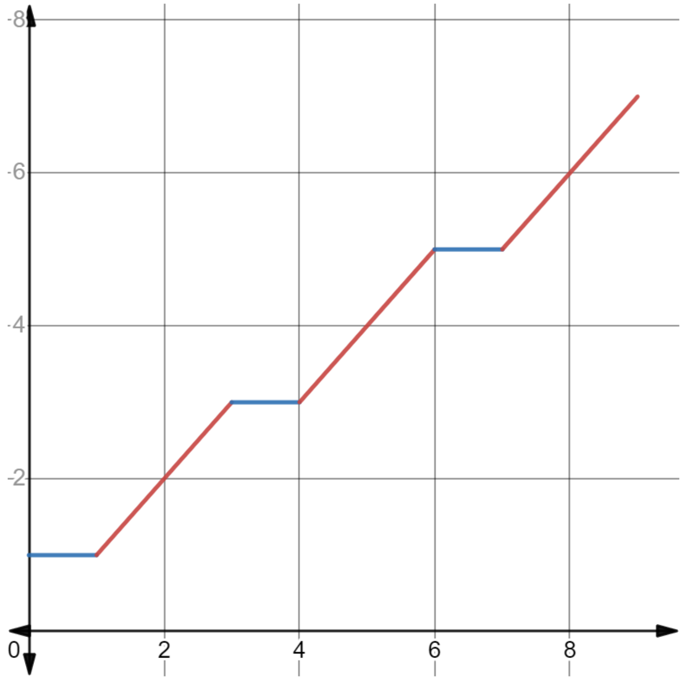
In Section 3.2, we described the fundamentals and applications of soft and hard tools. Soft tools predominantly focus on outlining concrete and graphical representations and schemes, with very meager amount of multitasking. Soft tools also aim to sketch as much guidance as possible and resemble a relatively swift and transparent process that is relatively easy to grasp the first time.

Hard tools, on the other hand, focus on the technical aspects, such as the design of mathematical models, algorithms, and computer simulations, to analyze and predict the behavior of complex systems. Hard tools often involve substantial multitasking and require multiple observations or repetitions to start grasping the given themes.

What are the advantages and disadvantages of soft and hard tools? Which systems are more geared toward applying soft tools versus hard tools? Sections 5.5.1 and 5.5.2 will thoroughly examine these details.

5.5.1 *Soft tools*

Soft tools graphically emphasize the essential features of a specific theme. The distinction of categories emerges either as different colors, patterns, decompositions, groupings, etc. The following graph is an example of a graphical soft tool and presents a system of horizontal blue lines and diagonal red lines on the corresponding restricted intervals:



Soft tools for hierarchical systems reveal specific attributes, such as easy accessibility, flexibility, scalability, and collaboration support. Soft tools particularly aim at improving communication, decision-making, information management, and performance evaluation.

Soft tools do present several disadvantages, challenges, and limitations. The first challenge involves the direct impact on the accuracy of the performance outcomes. Soft tools can be resistant to revising, changing, or adopting new tools and strategies. At times, soft tools can be incompatible with existing tools and systems. In addition, soft tools may not always describe all the necessary fragments and connections between the components. That is, they may not always be accurate and may have missing fragments.

5.5.2 *Hard tools*

Hard tools aim to indicate the interconnections between components of a complex design. The following solution to a recursive relation is an example of a mathematical hard tool. In fact, it is decomposed into different groups of patterns, colors, and substitutions, as illustrated in the formulation below:

$$
\begin{aligned}
x_0 &= 1,\\
x_1 &= 2x_0 + 2 = 2 + 2,\\
x_2 &= 2x_1 + 3 = 2 \cdot [2 + 2] + 3,\\
&= 2^2 + \left[2 \cdot 2^1 + 3 \cdot 2^0\right],\\
x_3 &= 2x_2 + 4 = 2 \cdot [2^2 + 2 \cdot 2^1 + 3 \cdot 2^0] + 4,\\
&= 2^3 + \left[2 \cdot 2^2 + 3 \cdot 2^1 + 4 \cdot 2^0\right],\\
x_4 &= 2x_3 + 5 = 2 \cdot [2^3 + 2 \cdot 2^2 + 3 \cdot 2^1 + 4 \cdot 2^0] + 5,\\
&= 2^4 + \left[2 \cdot 2^3 + 3 \cdot 2^2 + 4 \cdot 2^1 + 5 \cdot 2^0\right],\\
x_5 &= 2x_4 + 6 = 2 \cdot [2^4 + 2 \cdot 2^3 + 3 \cdot 2^2 + 4 \cdot 2^1 + 5 \cdot 2^0] + 6,\\
&= 2^5 + \left[2 \cdot 2^4 + 3 \cdot 2^3 + 4 \cdot 2^2 + 5 \cdot 2^1 + 6 \cdot 2^0\right],\\
&\ \vdots
\end{aligned}
$$

$$
x_n = 2^n + \left[\sum_{i=0}^{n-1} (i + 2) \cdot 2^{(n-1)-i}\right].
$$

Hard tools are structured, data-driven, and rely on quantitative data and well-defined methods for decision-making and problem-solving. Hard tools focus on optimization and often aim to maximize efficiency, minimize costs, and optimize resource allocation within hierarchical systems. Hard tools characterize predictive capabilities and can use historical data and trends to forecast future outcomes and inform decision-making. Hard tools can aid organizations in effectively allocating resources by identifying optimal allocation strategies.

Hard tools also aim to obtain quality, accurate, and current data. Hard tools focus on being compatible with organizational goals and strategies and on aligning with an organization's strategic objectives to ensure their effectiveness. It is essential for hard tools to integrate with existing tools, systems, and workflows to facilitate adoption and usage.

Several disadvantages, challenges, and limitations arise with hard tools. Hard tools are often dependent on accurate data. As a consequence, hard tools are only as effective as the quality and accuracy of the data they rely on. Limited adaptability can be encountered with hard tools. As a result, hard tools may not be as flexible as soft tools in adapting to complex or changing situations. Implementing and using hard tools can become a challenge for users without technical expertise. Furthermore, hard tools may disregard human factors and hence not account for the softer aspects of organizational dynamics, such as culture, communication, and individual motivations and orientations.

5.6 End of Chapter Summary

Sections 5.1–5.5 outline the similarities, contrasts, advantages, and disadvantages among various strategies and unfold the following questions: How much guidance is necessary to accomplish the essential objectives? When and how can you apply a specific method to achieve an assigned task? Which is more appropriate and accurate: concrete representation vs. abstract thinking, convergent or divergent thinking, continuous vs. emergent learning, soft vs. hard tools? When and how do you transition from one method to another? When and how do you combine different methods and maintain balance?

5.7 Further Thoughts

1. In Section 5.1, we discussed the contrasts between centralized and open management systems. How much guidance should be provided in open management systems in comparison to centralized management systems? What is the percentage distribution of managerial and leadership roles in each system?

2. In Sections 5.1.1 and 5.1.2, we discussed the fundamentals of centralized and open management systems. Do these systems overlap with common characteristics? Please explain.
3. In Section 5.2, we discussed the differences between concrete and abstract representation. How do you transition from concrete to abstract and make abstract representation more concrete and transparent? How many repetitions are necessary to start gaining a grasp of more abstract concepts in comparison to more concrete representations? Do concrete and abstract thinking overlap with common characteristics? Please explain.
4. In Section 5.4, we discussed the distinctions between convergent and divergent thinking. Which thinking method guides one to making quick decisions? Which method leads to making the right decisions? Do convergent and divergent thinking overlap with common characteristics? Please explain.
5. In Section 5.5, we discussed the disparities between soft and hard tools. Which tool is more flexible to changing environments and revisions? Which tool is compatible with continuous learning and emergent learning?

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Chapter 6

Leadership

In Section 1.2.2, we defined **leadership** as influential guidance to followers. Leadership can be interpreted as the ability to impact and navigate individuals, teams, or organizations to accomplish a common and ethical task. The corresponding quotes by Warren Bennis outline the fundamental traits of leadership and the contrasts between management and leadership:

> "The leader innovates while the manager administers."
> "The leader develops while the manager maintains."
> "The leader focuses on people while the manager focuses on systems and structure."

The following three sections (Sections 6.1–6.3), describe the specific features of each category of leadership. In particular, these three sections outline the recommended systematic schedule of leadership by linking individualized, collaborative, and experiential learning.

6.1 Transformational Leadership

The aims of **transformational leadership** are to influence positive changes in followers and encourage followers to become leaders. Transformational leadership stimulates changes to individuals and within social systems. According to James Burns (a leadership expert and presidential biographer), transformational leadership can be interpreted as follows: "leaders and followers make each other advance to a higher level of morality and motivation" (Burns, 2004). The primary tasks of transformational leaders are to inspire their followers to change their expectations, perceptions, and motivations to achieve common goals. Successful transformational leaders are tactical and strategic leaders.

Transformational leadership also unfolds openness to new thinking, talents for broadening minds, inspiration for participation, and acceptance of responsibility. Burns considers transformational leaders as those who can stimulate their followers to go beyond their comfort zone in order to achieve their goals.

In comparison to the transactional approach, transformational leadership is not based on a "give and take relationship" nor only on rewards and punishments. On the contrary, transformational leadership describes the leader's personality, traits, and ability to make a change by providing examples and articulating an energizing vision and challenging goals. Transformational leaders provide benefits for the team, organization, and/or community while portraying moral examples (Bass, 1990a; Burns, 2004).

The diagram in Figure 6.1 outlines the systematic scheme of the four I's of Bass's transformational leadership.

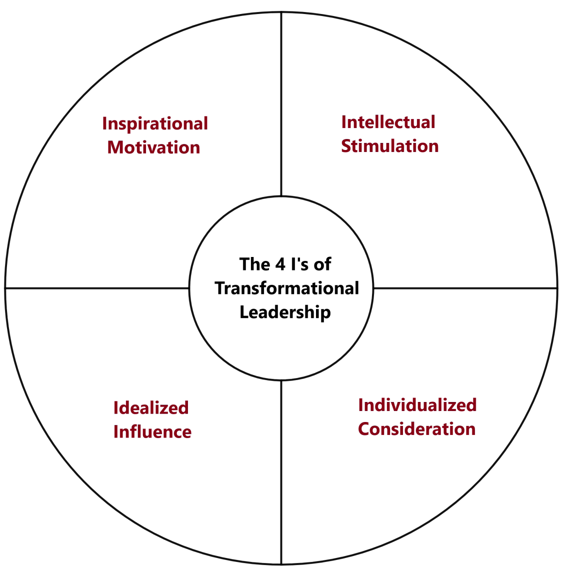


Figure 6.1. The 4 I's of Bass's transformational leadership.

Figure 6.1 presents idealized influence, inspirational motivation, intellectual stimulation, and individual consideration as the four critical factors of transformational leadership that sum up to performance beyond expectations.

Bernard M. Bass examined the psychological mechanisms that link transforming and transactional leadership. In fact, based on the work of James Burns, Bernard Bass aimed to accurately measure transformational leadership and precisely describe how it impacts the followers' motivation and performance (Bass, 1990a). **Bass's transformational leadership theory** (describes how it is essential for transformational leaders to earn and retain trust, honesty, respect, and admiration from their followers.

6.2 Sustainable Leadership

Sustainable leadership is an influence that delivers direction, alignment, and commitment while aiming to solve problems that address social, environmental, and economic issues and welcome an amiable working environment (McCauley, 2014). Sustainable leadership is a schematic influence that links a group of people working together to design a shared and beneficial vision for change, coordinate their activities, and foster personal commitment to collective success (Quinn and D'Amato, 2008). The diagram in Figure 6.2 portrays the principles of the hierarchical scheme of sustainable leadership:

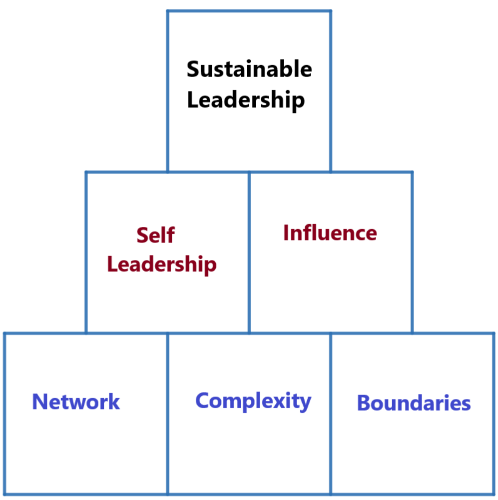


Figure 6.2. The principles of sustainable leadership.

Self-leadership is the first critical characteristic of sustainable leadership. It addresses successful individualized learning, which is the ability of a leader to be his/her own boss. Successful individualized learning then transitions to collaborative learning and hence leading others.

Influence is the next vital feature of sustainable leadership. Dr. Ken Blanchard, the co-developer of the widely used **situational leadership model**, reminds us that "the key to successful leadership is influence, not authority" (Blanchard, 2013). Influence can be interpreted as selling your story or practice to others. Effective influence encourages, stimulates, and inspires followers to be engaged, productive, and successful.

Networking is another crucial attribute of sustainable leadership. Networking opens new doors and windows of opportunity for new ideas, practices, and collaborations. Networking also welcomes the leader and his/her followers to a diverse cross-disciplinary environment, which includes diverse educational backgrounds and experiences.

Complexity is a frequently occurring phenomenon in sustainable leadership. In fact, it welcomes creativity and requires thinking and imagination beyond the boundaries of the leader's comfort zone to solve challenging problems. Complexity expands the leader's experiences, intuitions, comfort zones, horizons, and frontiers.

Boundaries naturally expand as sustainable leadership grows. In particular, boundaries present new international horizons and frontiers, expand the comfort zones, and unfold a new diverse international and cross-cultural environment for the leader and his/her followers. Boundaries also welcome the leader and his/her followers to new cross-disciplinary and cross-cultural exchanges and to a diverse collaborative and experiential learning environment. Boundaries expand and blend individualized and collaborative learning.

Sustainable leadership presents the following traits: thought leaders, adaptive leaders, team leaders, boundary spanning leaders, and trusted advisors.

6.3 Primal Leadership

Primal leadership is the emotional dimension of leadership that addresses emotional intelligence, experiences, and intuition. In fact, a primal leader focuses on regulating emotions and feelings and manages the emotions of his/her followers by guiding them in a positive direction while clearing negative emotions. This is referred to as **resonance leadership**. The principles of primal leadership are parallel to the fundamentals of the dynamics of change described in Section 2.3.1.

Emotional regulation is interpreted as "the processes by influencing which emotions we have, when we have them, and how we experience and express them" (Gross, 1998). It guides us in managing and regulating our emotions to respond effectively to challenging circumstances without overreacting. This is analogous to the quote "It is not what happens, but how you react" by William Clinton. Primal leadership and emotional regulation lead to a balance between emotional thinking and rational thinking, as presented in Figure 6.3.

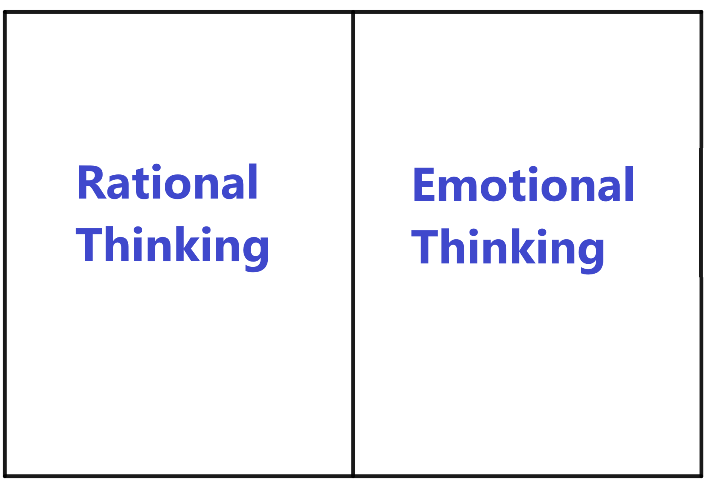


Figure 6.3. Emotional vs. rational thinking.

Observe that Figure 6.3 is similar to the structure of the 80/20 rule outlined in Section 2.5.1. In Section 8.2.1, we extend Figure 6.3 to the **three minds model** described in Figure 8.7 by considering the overlaps between rational and emotional thinking. More thorough details on primal leadership, resonance leadership, emotional intelligence, and emotional regulation will be discussed in Sections 8.1 and 8.2.

The diagram in Figure 6.4 displays the attributes and the recommended scheme of primal leadership.

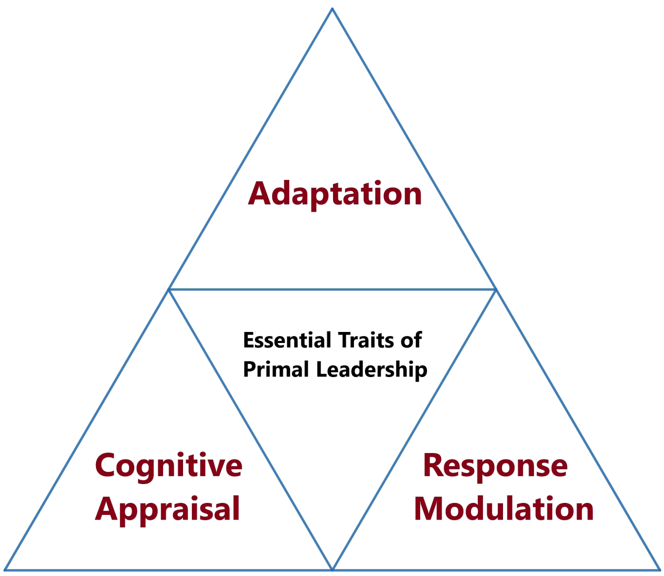


Figure 6.4. The attributes of primal leadership.

Adaptation is the first essential trait of primal leadership. In fact, adaptation focuses on diversity, tolerance, equity, and inclusion. It is critical for the leader and his/her followers to adapt to each other, to new circumstances, and to new working environments.

Cognitive appraisal is the next vital feature of primal leadership, as it highlights the essence of flexibility and alternative methods. It addresses designing and implementing alternative methods and reinforces the quote, "When one door closes, the other one opens."

Response modulation is another important attribute of primal leadership, as it focuses on regulating emotions and reactions and leans toward optimistic outlooks. Is the glass half empty or half full? It is not what happens, but how you react to a specific circumstance.

6.4 Leading vs. Following

Every leader has an educational base of experiences and knowledge that he or she applies to design new innovations and achieve the expected destination or outcome. While working to achieve the desired aims, it is vital to provide a stimulating and amiable working environment by being as flexible as possible. This includes flexibility to feedback, adaptation to the new environment, developing and enhancing two-directional communication and exchange of ideas, and acknowledging and balancing educational, experiential, and cultural differences.

Every leader will encounter unfamiliar territories as limited resources arise and problems occur that go beyond his/her experiences and trained intuitions. How do you handle these circumstances as a leader and successfully explore new frontiers? When is the right time to obtain feedback and recommendations from more experienced colleagues and let them take the lead? The diagram in Figure 6.5 addresses these questions and reveals the fundamental essence and recommended scheme of the balance between leading and following, together with flexibility.

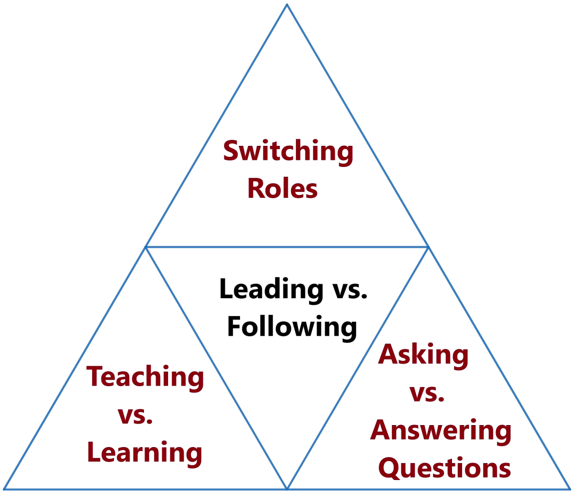


Figure 6.5. Essence of leading vs. following.

6.4.1 *Switching leadership roles*

Inviting your followers to switch leadership roles is the first critical essence of leading vs. following. This is also a critical leadership characteristic that embraces diversity, equity, and inclusion as it stimulates participation and discussions. When is the right time to invite your followers to take the lead? How do you encourage your followers to take the lead? This can be implemented by inviting your students to solve problems during class time, encouraging them to check for mistakes and missing fragments, and asking the right questions that initiate robust discussions during class and seminar. The diagram in Figure 6.6 unfolds the recommended benefits of switching leadership roles.

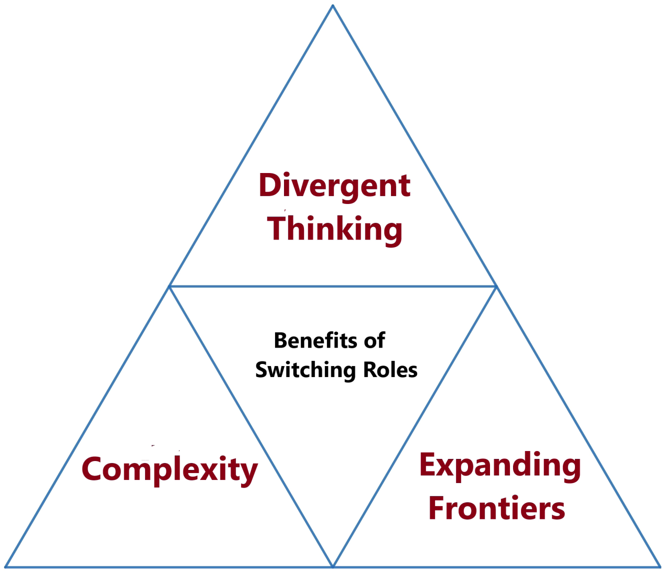


Figure 6.6. Why switch leadership roles?

First, switching leadership roles guides you to **creativity and divergent thinking**, as it focuses on designing creative thoughts by exploring numerous solutions to a specific problem. Divergent thinking aims to discover indirect and creative methods that require us to think outside our comfort zone and analyze problems from new directions to discover new innovative solutions. In particular, divergent thinking unfolds the fundamentals of diversity, individualized and collaborative learning, and the two-directional exchange of ideas. Divergent thinking also prepares you for cross-disciplinary and cross-cultural collaborations.

Switching leadership roles also reveals the fundamentals of **complexity** as it examines multiple interactions between different components and concepts. In addition, it prepares us to compare the similarities and contrasts between different components and concepts.

Switching leadership roles naturally aids in **widening your horizons** as it expands your experiences, intuitions, analytical skills, cognitive skills, and comfort zones.

When is the right time to hand over leadership responsibilities to your followers? What leadership tasks and how many leadership tasks do you initially assign to your followers?

6.4.2 *Teaching vs. learning*

In the field of pedagogy, learning by teaching is a specific systematic teaching scheme where the students learn the concepts by preparing lesson plans in order to effectively convey the concepts to their classmates. This method was designed by Jean-Pol Martin during the 1980s. Learning by teaching develops and enhances communication skills, analytical skills, cognitive skills, and the two-directional exchange of ideas. The following quotes reveal the essential characteristics of learning:

> "Always walk through life as if you have something new to learn and you will." — Vernon Howard.
> "The only person who is educated is the one who has learned how to learn and change." — Carl Rogers.
> "Man's mind, once stretched by a new idea, never regains its original dimensions." — Oliver Wendell Holmes.

In Section 1.1.1, we discussed the primary characteristics of *The Fifth Discipline: The Art and Practice of the Learning Organization*. Peter Senge defines learning organization as the facilitation of individualized and collaborative learning, and reveals the rudiments of continuous learning discussed in Section 5.4.1. The diagram in Figure 6.7 presents the fundamentals of the teaching vs. learning cycle.

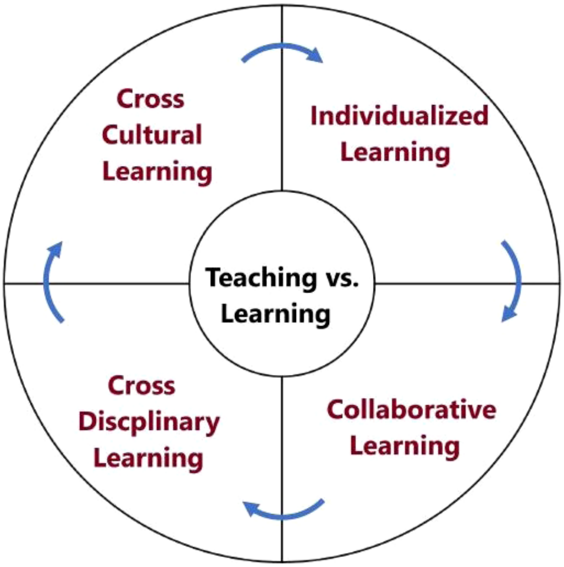


Figure 6.7. The Fundamentals of the teaching vs. learning cycle.

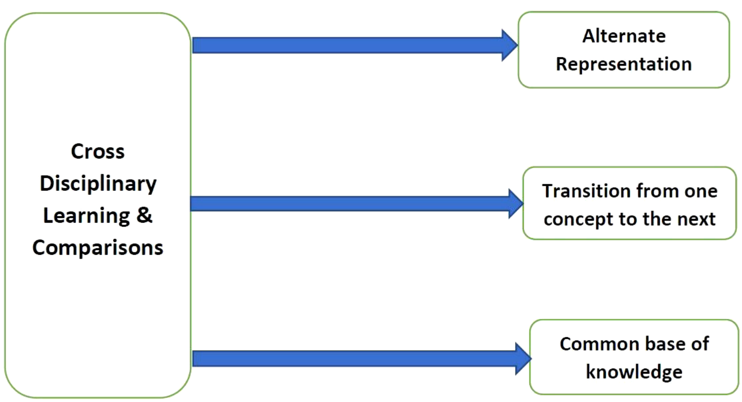
The first step of the teaching vs. learning cycle guides you to the principles of **individualized learning**. In fact, individualized learning welcomes diversity, as "personalization presents wide diversity in the learning components and how they are combined" and that "maybe personalization has to come through how the students engage with the content and outcomes they produce rather than from the media through which knowledge and skills development is channelled" (Nandigam *et al.*, 2014).

Individualized learning originated from Howard Gardner's theory of multiple intelligences. The rudiments of individualized learning include individual students' interests, their needs and abilities, and the identification of the best learning style for each student (Good and Brophy, 1995). Individualized learning strategies present numerous advantages over traditional learning methods as they are consistent with constructivist learning theories (Savery and Duffy, 1995; Pritchard, 2013). These theories suggest that learning is active and perpetual, and students' knowledge expands based on their experiences.

The second phase of the teaching vs. learning cycle unfolds the rudiments of **collaborative learning**. Collaborative learning focuses on divergent thinking, flexibility, feedback, diversity, educational contrasts, experiential contrasts, and cultural contrasts. What new techniques can you learn, and what new practices can you teach others?

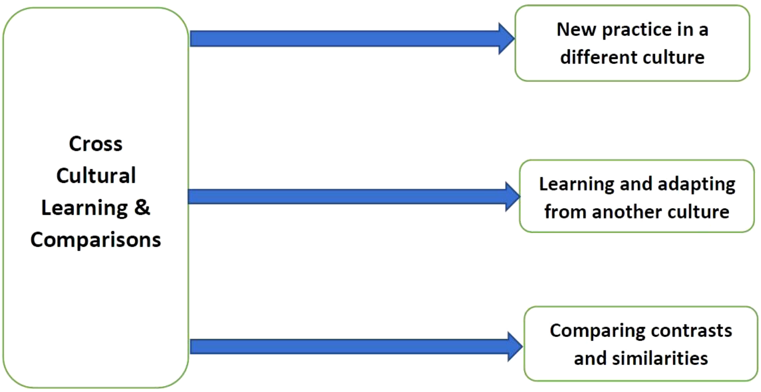
Collaborative learning compares analogies, detects contrasts, and bridges different concepts together. Connecting similarities and differences between concepts, disciplines, and cultures expands your horizons and presents new perspectives.

Cross-disciplinary learning is a vital part of the teaching vs. learning cycle, and it delves into deeper understanding and appreciation of complexity. It especially highlights the interaction between components of a system that can have quite different characteristics. How do different departments interact with each other in an organization? How do different disciplines in a university interact with each other? The consequent diagram outlines the fundamental attributes of cross-disciplinary comparisons and learning.



Cross-cultural learning is a critical fragment of the teaching vs. learning cycle as it focuses on cross-cultural diversity. It especially indicates specific similarities and contrasts that emerge between cultures, such as different educational and experiential contrasts.

What ideas can you learn from other cultures, and what ideas can you welcome to other cultures? What are the similarities and contrasts that emerge? What opportunities and challenges do the similarities and contrasts present? The consequent diagram outlines the fundamental attributes of cross-cultural comparisons and learning.



6.4.3 *Asking vs. answering questions*

Asking vs. answering questions is an essential part of the teaching and learning process, as it is important to detect specific details and answer questions correctly, accurately, and effectively. Asking related and detailed questions reveals your individualized discovery learning path and enhances your collaborative learning, problem-solving skills, critical thinking skills, and comparison skills.

Asking and answering related and detailed questions also presents the fundamentals of complexity and diversity as it widens your base of knowledge, horizons, and comfort zone. In particular, asking and answering questions is a vital fragment of the teaching and learning process, as it encourages to detect the missing gaps and bridging concepts.

When is the right time to ask a specific question? When is the right moment to present your followers with opportunities to ask questions? The diagram in Figure 6.8 presents the rudiments of the asking vs. answering questions cycle.

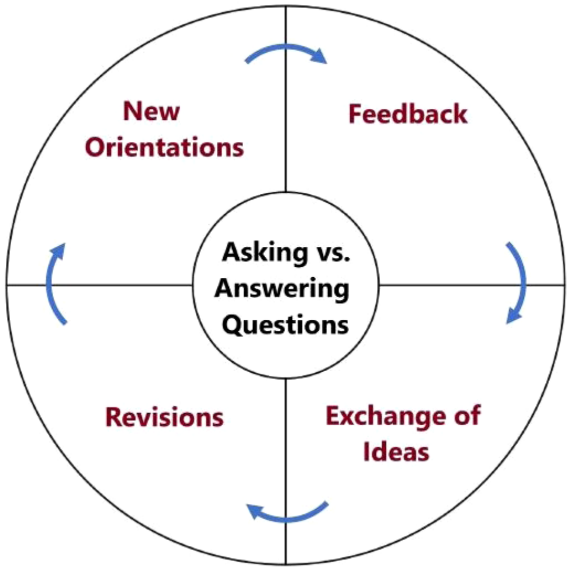


Figure 6.8. Asking vs. answering questions cycle.

First, the asking vs. answering questions cycle guides you to **feedback and recommendations**. You gain valuable feedback while asking questions and answering questions. These include suggestions for new ideas to try, emphasizing mistakes and missing fragments, and recommending alternate solutions. Feedback and recommendations can emerge in students' evaluations and customers' evaluations and surveys.

Feedback and recommendations promote divergent thinking, lateral thinking, and the two-directional **exchange of ideas**. Feedback then leads you to supplemental acquaintance with complexity and diversity. What do you see that your colleagues do not see? What do your colleagues see that you do not see? How do you blend these potential and diverse thoughts together?

The two-directional **exchange of ideas** then navigates you to **revisions** and improvements that aim to solve specific problems. How do you resolve a certain problem, and how do you improve and design a better and more efficient system?

Revisions then direct you to **new innovative orientations** to discover new frontiers and achievements. In fact, revisions lead to transitions from traditional methods to new ones. What do the two methods have in common, and what are the contrasts? The diagram in Figure 6.9 addresses these questions and presents the Venn diagram model of traditional vs. new methods.

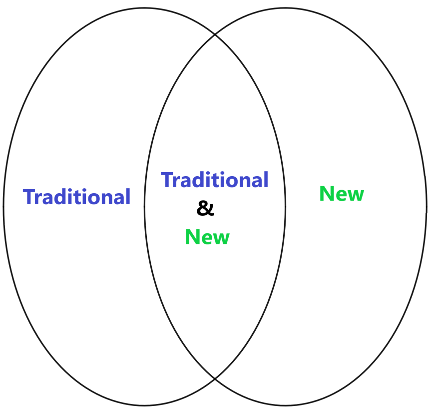


Figure 6.9. Traditional vs. new methods.

Figure 6.9 can be applied to transition from traditional to an online teaching and learning environment. What teaching techniques can be recycled, and what new innovative teaching techniques will arise?

Figure 6.8 guides you to asking the right questions that focus on distinct details that are not easily noticeable and require very thorough vigilance. More details on asking the right questions will be examined in Section 8.2.2.

6.5 End of Chapter Summary

Leadership is more agent-based oriented and is an important trait that focuses on designing ideas, revising ideas, and achieving outcomes. In the meantime, while achieving short- and long-term goals, it is essential for leaders to present an amiable, trustworthy, and diverse working environment. Effective leadership also involves various roles in order to thoroughly understand complex systems and to keep up with current trends. Chapter 7 will rigorously examine various leadership roles and their aims and desired destinations.

6.6 Further Thoughts

1. In Section 6.1, we discussed the fundamentals of transformational leadership. Is transformational leadership more compatible with continuous learning or emergent learning?
2. In Section 6.3, we discussed the essence of primal leadership. Is primal leadership more compatible with convergent thinking or divergent thinking? Is primal leadership more compatible with continuous learning or emergent learning?
3. In Sections 6.1–6.3, we discussed the three categories of leadership. Which category of leadership do you apply to stimulate new problem-solving techniques? Which category of leadership do you apply to resolving conflicts? Which category of leadership do you apply to design an effective two-directional exchange of ideas?
4. The concept of self-leadership is first discussed under sustainable leadership in Section 6.2. In particular, how does self-leadership arise from the primal leadership discussed in Section 6.3?

Chapter 7

Leadership Roles

John Dewey (1859–1952) was an American philosopher, psychologist, and educational reformer. He significantly contributed to social and educational reforms. In particular, John Dewey strongly enhanced democracy in education and journalism. His aims were also oriented toward promoting intelligence and plurality in education. The following quotes by John Dewey reveal the features of leadership roles in education:

> "Education is a social process; education is growth; education is not preparation for life but is life itself."
> "The most important attitude that can be formed is that of desire to go on learning."
> "Democracy and the one, ultimate, ethical ideal of humanity are to my mind synonymous."

John Dewey published *The School and Society* (Childs, 1967) and *Democracy and Education* (Dewey, 1916). First, Dewey claims that schools emphasize the mastery of facts and disciplining of bodies rather than training students to be ethical and active citizens in society. Second, Dewey affirms that schools orient students toward compliance with authoritarian work and political structures rather than training students to be reflective, autonomous, and ethical beings capable of arriving at social truths by applying critical thinking skills. Dewey also asserts that schools discourage students from pursuing their individual and communal inquiry, which limits divergent thinking as well as individualized, creative, and innovative learning (Dewey, 1899, 1916). John Dewey believed that leadership roles in education should include stimulating intellectual growth and responsibilities while enhancing character, new knowledge, and skills.

In 1997, Peter Senge established the Society for Organizational Learning. In 1990, Senge published his book *The Fifth Discipline: The Art and Practice of the Learning Organization.* He describes that "learning organizations" aim to continually expand their capacity to achieve the desired results. Learning organizations present new and expansive thinking patterns. In particular, they focus on continuous learning patterns that lead to understanding the whole.

Peter Senge also claims that it is essential for learning organizations to adapt quickly and effectively to changing circumstances in order to achieve the desired learning outcomes. Sketching the scheme of the intended or desired outcomes is the first essential criterion for learning organizations. The ability to recognize that the initial orientation is different with respect to the desired outcome is the second essential criterion for learning organizations. The subsequent vital criterion is to detect the sources of the mismatches and correct them. The three criteria for learning organizations unfold the principles of an effective leadership role in education.

Heuer and King (2004) argue that while online instruction shares many features with the traditional teaching and learning modality, it offers unique attributes such as flexibility, learning at any time and any place, along with time for reflection and learners' anonymity. As a result, the instructor's role in the online environment has become more complex. Therefore, due to these unique attributes, faculty are forced to rethink their roles in online teaching and learning, which differ from those in teaching in a traditional face-to-face environment (Grosse, 2004; Panda and Mishra, 2007; Lee and Busch, 2005). The diagram in Figure 7.1 outlines the four leadership roles in education.

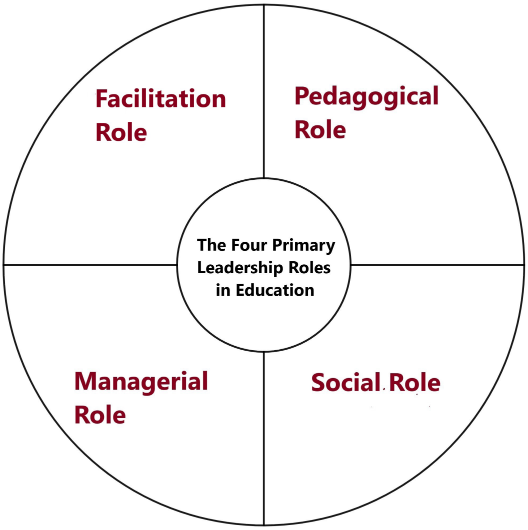


Figure 7.1. The Four primary leadership roles in education.

The upcoming sections focus on what objectives each of the roles presented in Figure 7.1 aims to accomplish and address the following practical goal: How can instructors use a virtual platform to design a tutorial situation with discussions and inviting presentations as well as more personal interactions with their students?

7.1 Pedagogical Role

The **pedagogical role** of a faculty member focuses on analyzing, revising, and evolving teaching techniques and innovations that lead students to reaching the expected course outcomes, individualized and collaborative learning, and learning how to communicate effectively and creatively in the online environment.

The facilitation of learning is, in fact, the key component of the quality of creative online teaching and learning. The interaction between the instructor and the students either strengthens or weakens the quality of creative outcomes in the online learning environment. Ultimately, the students' ability to master the course concepts and improve critical thinking, problem-solving, comparison, and communication skills are the hallmarks of higher education.

These preparations are essential to enhancing creativity and innovation and are foundational to building and widening cross-cultural and global knowledge and discovering solutions to world-wide challenges. These skills are crucial for widening perspectives in higher education and extending access through distance learning (Andrade, 2015). The corresponding diagram in Figure 7.2 illustrates the three rudiments of the pedagogical role.

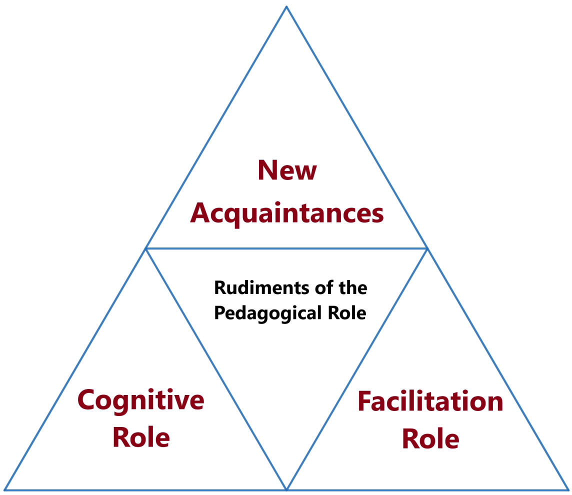


Figure 7.2. The Pedagogical Role in the online environment.

1. The pedagogical role begins with **acquainting** students with the unique characteristics of the online course, presenting them with a welcoming selling story of why they should take the course online, the course's objectives, and new discoveries that extend from the bases of previous courses. This is especially critical during the very first class for addressing the following students' concerns: What new knowledge will the students acquire? What

new communication skills will the students obtain? What new analytical and critical thinking skills will the students gain? What is the course's evaluation system?

2. The enhanced visual pedagogical role then seeks to maintain a more creative cognitive process, and the **cognitive role** directs the students' focus on the perception, learning process, process of information, analytical and critical thinking, and communication and analysis.
3. An effective pedagogical role naturally leads to the **facilitation role**. This role orients your students toward a hands-on teaching and learning style. This encourages your student to self-learn while assisting them with questions and emphasizing their mistakes. Hands-on practice is essential for your students to interpret concepts on a deeper level.

7.2 Social Role

The **social role** of a faculty member focuses on designing a stimulating, social, confident, trustworthy, and comfortable atmosphere that inspires students to learn. The following quotes by John Dewey and Peter Senge emphasize the essential characteristics of the social role in education:

> "Social role of a teacher aims to structure educational environments to promote educative learning experiences, those that change the learner in such a way as to promote continued learning and growth." — John Dewey.
> "Social Role of a teacher orients to emphasizing 'Survival Learning' or 'Adaptive Learning'. 'Adaptive Learning' enhances our abilities to create and design." — Peter Senge.

The social role is especially vital in asynchronous online teaching and learning environment. The cognate diagram in Figure 7.3 presents the three traits of the social role.

1. The social role commences with welcoming your students to an **amiable teaching and learning environment**. The first

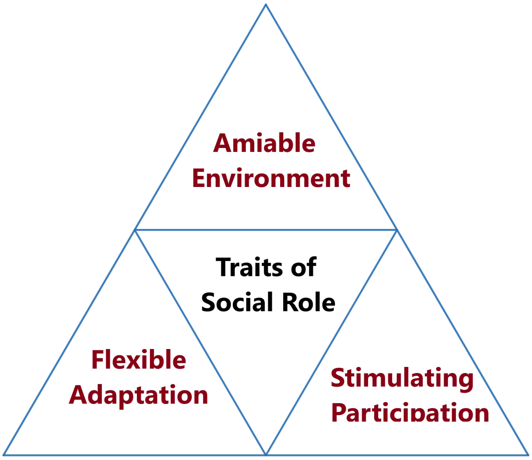


Figure 7.3. The three traits of the social role.

critical step is to establish a stimulating working atmosphere and trust between you and your students. The social role is also aimed at keeping students focused and engaged.

2. **Flexible adaption** is another vital characteristic of the social role in the online teaching and learning environment. Switching to an online environment does require acclimation, and it is important to offer your students more flexibility while they are acclimating. This ideology resembles a stimulating and supportive attitude toward your students in the new environment by giving them a fair chance to learn and succeed in your course.
3. Faculty members' effective social role is to encourage their students to **participate**. To design a welcoming environment together with participation, it is important to encourage your students to ask questions and detect and emphasize mistakes. An important aspect of socializing is asking your students questions and keeping them engaged. These questions include: In which step did the mistake occur? What is wrong with this diagram? How do we proceed from this step?

The social role gradually shifts to the managerial role.

7.3 Managerial Role

The managerial role is vital as it describes the overall character and quality of teaching of a faculty member. Students' teaching evaluations are strongly based on the faculty member's managerial role. In fact, he/she receives specific feedback and future recommendations from students based on his/her managerial role.

The **managerial role** of a faculty member includes: posting notes, videos, schedules, and deadlines; presenting the course topics, and leading the pace of the topics and the course; and presenting the course rules and grading policies. These responsibilities comprise the submission of assignments and tests, the necessary work that is required, and the percentage decomposition of the course grade. The following two sections (Sections 7.3.1 and 7.3.2), focus on the analogies and traits of the managerial role.

7.3.1 *Analogs of the managerial role*

The diagram in Figure 7.4 presents the primary analogs of the management role in the online environment.

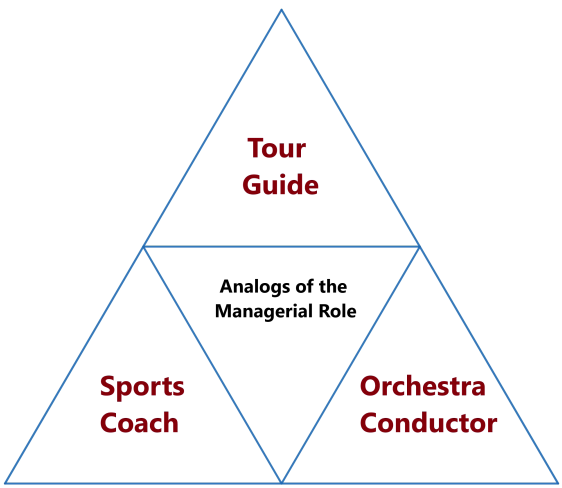


Figure 7.4. Primary analogs of the managerial role.

1. The managerial role of a faculty member can be viewed as a **tour guide**. As a tour guide, it is important to provide your students with a road map or a scheme of the entire course, the topics, each concept, and the details in each example and homework problem. This tactic sketches an overall outline and navigates students to reaching the expected learning outcomes. From our personal experiences, it is important to present such a scheme in the course outline, using a guided platform such as MyCourses, during each lecture and on graded assignments and tests.
2. The managerial role of a faculty member can be interpreted as a **sports coach**. As a sports coach, it is crucial to reinforce the fundamentals of concepts by providing your students prompt and graded feedback with comments emphasizing where and why mistakes occurred while the students' minds are fresh. This strategy keeps a faculty member abreast of the students' progress on mastering the concepts and forces the students to keep up with the course material. As a sports coach, it is also pertinent to keep the students abreast of the current concepts and the schedule of deadlines and tests.
3. The managerial role of a faculty member can be regarded as an **orchestra conductor**. As an orchestra conductor, it is pertinent to present the similarities and contrasts between different concepts and build connections between different concepts for your students. This practice will enhance your students' analytical and critical thinking skills and expand your students' experiences, intuitions, and comfort zones. The main goal is to propel your students not only beyond their comfort zones and environment but also toward cross-disciplinary and cross-cultural comparisons.

7.3.2 *Traits of the managerial role*

The consequent diagram in Figure 7.5 traces the three traits of the managerial role in education.

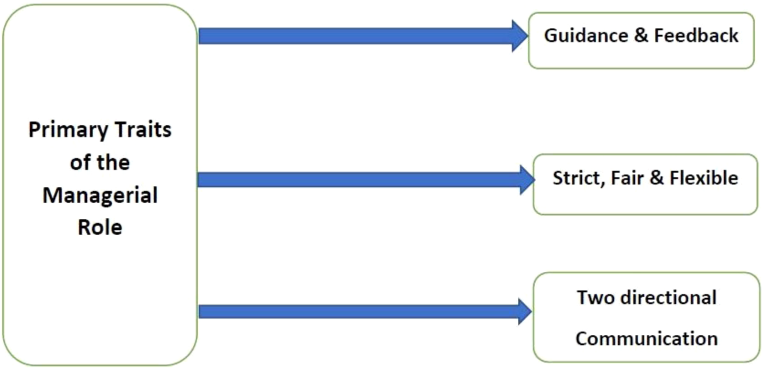


Figure 7.5. The primary traits of the managerial role.

1. An effective managerial role of a faculty member recommends to provide precise **guidance and feedback** to your students. It is especially critical to provide positive and supportive feedback to your students. This guided feedback indicates what and where the problems are and encourages your students to correct them and gain a stronger grasp of the concepts.
2. A solid managerial role for a faculty member is to be **strict, fair, and flexible** with your students. These aspects portray shared responsibilities between you and your students. This includes informing your students on the first day of class about the course and grading policies and posting submission deadlines and test dates.

   It is important to keep your students abreast of the upcoming deadlines and test dates and emphasize the frequent mistakes that occurred on each homework assignment while rigorously reviewing each problem effectively. Some flexibility with your deadlines and providing alternative test times are crucial to giving students additional chances to get acclimated to the new teaching and learning environment and to accommodate their working schedules. This offers your students additional support and stimulus to try and succeed.

3. A constructive managerial role builds a **two-directional communication** with your students. It is essential to encourage your students to communicate with you about their progress and challenges, about late submission of assignments, and especially about not being available to take scheduled tests. This encourages students to communicate more, which will give you a chance to prevent and resolve potential problems with late submissions, missed scheduled tests, and other problems.

   The two-directional communication aspect of the managerial role addresses leading vs. following and teaching vs. facilitating. Further, it presents leadership opportunities for your students. First, this involves stimulating your students to work on many practice problems and expand their own interpretation of the concepts. This increases your students' analytical and critical thinking skills and encourages them to detect their mistakes, your mistakes, and others' mistakes and to ask further questions. Two-directional communication will strengthen the principles of "you do not learn and get better by only observing others," "practice makes perfect," and "80% of learning occurs outside of class." This also reinforces the concepts' fundamentals and leads to finding alternative solutions to specific problems.

7.4 Facilitation Role

The facilitation role for faculty members is an essential part of the social and managerial roles in the teaching and learning environment, as it presents a guided scheme and path for students to learn on their own. The facilitation role emphasizes the importance of two-directional communication between you and your students and indicates shared responsibilities. The primary role of the facilitator is to retain communication with students outside of class and let the learner take the lead and discover his/her own learning path with alternative methods and thinking. This plays an especially critical role in the asynchronous online environment, as there are no lectures and students learn the material on their own with either very limited or no guidance. Sections 7.4.1 and 7.4.2 will examine the specific attributes of facilitation.

7.4.1 *Facilitation*

Facilitation is defined as the act of engaging participants in creating, discovering, and applying various learning principles. A facilitator plans, guides, and manages a group to achieve a common group goal. To facilitate effectively, a facilitator must be objective and emphasize the essence of "group process" and "group dynamics." In-depth facilitation training and practice have successfully prepared the extension staff to help groups achieve positive and influential changes (Cyr, 2008a, 2008b). Facilitative strategies concentrate on the process and relationships and on producing positive and effective results.

In addition to group processes and conflict resolution, facilitation is a pertinent role in individualized learning, especially in the online teaching and learning environment. Facilitation guides the learner to his or her own interpretations of concepts and aims to achieve successful outcomes. Facilitation is highly student-centered and student-oriented and is devoted to learning. Furthermore, it navigates students to discover their own learning styles. Facilitation also addresses how to handle real-life circumstances, find practical solutions by discovering alternatives, and connect choices with consequences and outcomes. The consequent diagram in Figure 7.6 outlines the three instrumental characteristics of the facilitation role.

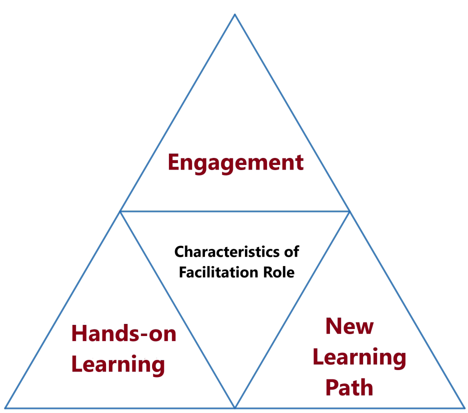


Figure 7.6. Characteristics of the facilitation role.

1. The diagram in Figure 7.7 presents the three instrumental attributes of engagement and the facilitation role.

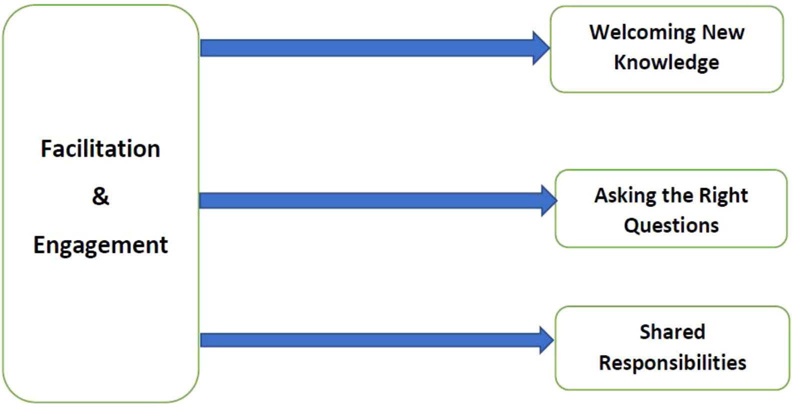


Figure 7.7. Facilitation role & engagement.

1.1. Influential facilitation, together with engagement, begins with **welcoming new knowledge** to your students and persuading them into understanding why they should take your course and what new knowledge, communication, analytical, and critical thinking skills they will gain from it. In addition, it involves emphasizing to your students how the new competence acquired in the course will guide them to future undergraduate-level courses, graduate-level courses, and in the professional world.

1.2. Constructive facilitation, together with engagement, focuses on **asking the right questions**. These are the questions that ignite students' curiosities and navigate them to new recognitions. In fact, these questions emphasize the accurate detection of unsolved problems and indicate alternative solutions, more efficient solutions, new solutions, and the expansion of their current knowledge. Asking the right questions entices students to design their your own learning path to discoveries of new concepts and detect similarities and contrasts between concepts.

1.3. Productive facilitation, together with engagement unfolds **shared responsibilities**. The dual responsibilities of both the instructor and the students should be stated clearly in the course syllabus and outline and should also be indicated on the first day of class and throughout the course.

A faculty member's responsibilities include answering questions in class and outside of class, indicating the frequent mistakes that occur on practice problems and homework assignments, assisting students with technical questions and issues, and assisting students with alternate testing days and times. It is important to be as flexible as possible and offer several options to students while addressing their concerns.

The students' responsibilities involve informing their instructor about struggles with understanding concepts, late submissions of assignments, technical problems, alternative testing times, and other problems. This communication is pertinent to giving the faculty member a chance to resolve a problem as quickly as possible. In addition, students' responsibilities are to detect and emphasize mistakes, suggest more efficient solutions, and advocate supplemental recommendations.

2. Hands-on learning and experiential learning are essential parts of the learning process as they focus on **individualizing learning** styles and preparations, which is the primary focus of education for all students (with and without classified learning disabilities) (Tomlinson, 1999). The consequent diagram in Figure 7.8 indicates the four primary experiential learning strategies in the online environment (Weinstein and Mayer, 1983).

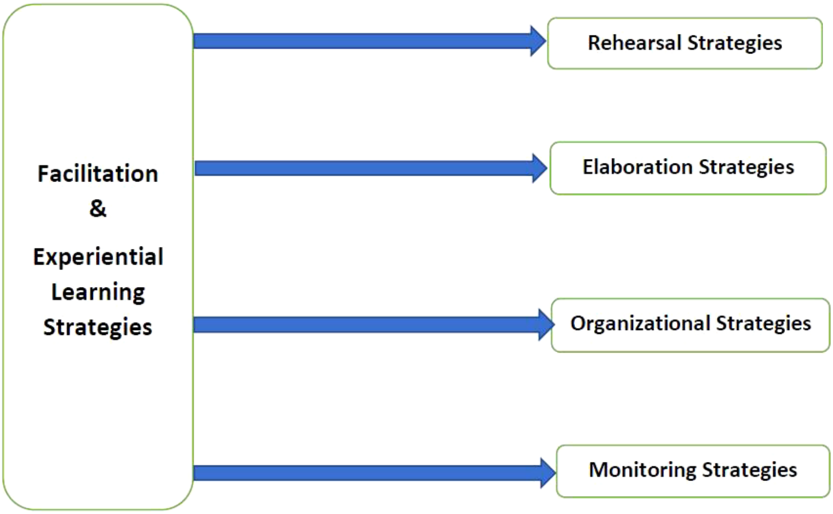


Figure 7.8. The Experiential learning strategies.

2.1. **Rehearsal strategies** highlight the essence of repetitions, revisions, and the expansion of cognition. Repetitions are necessary to start processing the concepts. Revisions are vital to strengthen the interpretation. Repetitions and revisions then navigate to the expansion of cognition.
2.2. **Elaboration strategies** involve absorbing, reflecting, and summarizing. Absorbing specific details is the first critical step in getting acquainted with new fundamentals. Reflecting and summarizing what has been absorbed is vital to retaining the newly learned fundamentals, especially to study further concepts.
2.3. **Organizational strategies** entail outlining a guided and systematic scheme. This scheme outlines all the necessary fragments of a system, the ordering of the fragments, and the connections between the fragments. A guided and systematic scheme resembles a graphical presentation of a specific concept or method and how it is applied.
2.4. **Monitoring strategies** address detecting mistakes and missing details. Making mistakes, learning from mistakes, and reflecting back on the corrected mistakes is an essential part

of the learning process and relates to the following pedagogical principle: "You do not learn unless you make mistakes."

3. Paving a new learning path to new discoveries reveals individualized learning. **Individualized learning** is essential, as each student is unique and has his/her personal learning style and preparations. It also offers students a flexible and personalized interpretation and rate of grasping the concepts, either analytically or graphically. Individualized learning originated from Howard Gardner's theory of multiple intelligences (Johnson and Onwuegbuzie, 2004). The rudiments of individualized learning include individual students' interests, their needs and abilities, and the identification of the best learning style for each student (Good and Brophy, 1995). Individualized learning strategies present numerous advantages over traditional learning methods as they are consistent with constructivist learning theories (Savery and Duffy, 1995; Pritchard, 2013). These theories suggest that learning is active and perpetual and that students' knowledge expands based on their experiences.

   Individualized learning can also be interpreted as the "shaping of students' learning activities and the curriculum/knowledge content that reflect the input and interests of students." First, this implies that students can choose how they learn and design their own curriculum and learning environment. Second, it also implies that student learning needs, interests, and capabilities determine the pace of learning.

   Individualized learning welcomes diversity as "personalization presents wide diversity in the learning components and how they are combined" and "maybe personalization has to come through how the students engage with the content and outcomes they produce rather than from the media through which knowledge and skills development is channelled."

7.4.2 *Organizational learning*

The facilitation role also leads to organizational learning. In Sections 1.1.1 and 6.4.2, we defined learning organization as the facilitation of learning. Peter Senge defines **organizational learning** as the process of designing, retaining, and transferring knowledge and gaining and expanding experiences. In fact, gaining and expanding experience leads to revisions, the development of knowledge, and influential changes (Argote and Hora, 2017). These include the increase in positive outcomes, efficiency in production, and progress in the learning curve. The following diagram in Figure 7.9 presents the organizational learning community cycle.

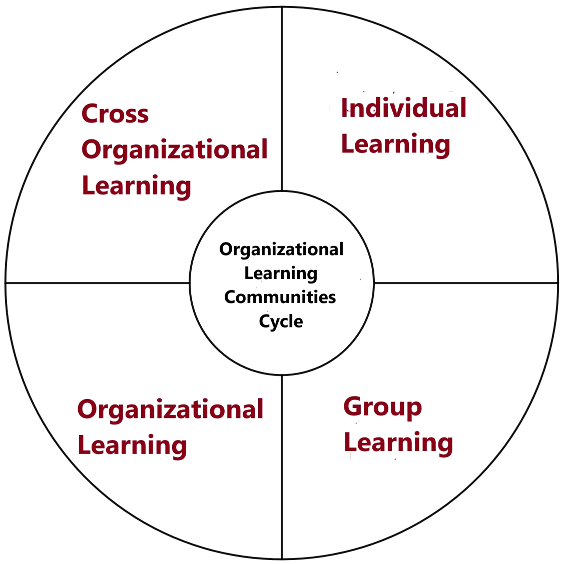


Figure 7.9. Knowledge & organizational learning cycle.

Individual learning, or **individualized learning**, is the initial phase of the learning community cycle. Each person learns new skills and concepts and gains experiences at his/her own pace with his/her individualized learning style. An individual can decide whether or not to share their knowledge with the rest of the group. It is also important to share individual knowledge with others. In fact, if an individual decides not to share his/her knowledge, the group loses this knowledge (Wilson *et al.*, 2007). In their study of software development, Boh *et al.* (2007) found that each individual was more productive in his/her specialty or focused studies.

Group learning is the next step of the learning community cycle when individual learning transitions to group learning or individualized learning transitions to collaborative learning. Group learning naturally arises when individuals share their gained knowledge and experience with others. Group learning is a learning process that involves providing feedback and applying it to make future revisions and improvements. It also involves error detection, correction, interpretation, and integration. Reagans *et al.* (2005) conducted research on group learning by observing joint-replacement surgeries in teaching hospitals and concluded that "increased experience working together in a team promoted better coordination and teamwork" (Edmondson and Mcmanus, 2007). Teamwork presents opportunities to share knowledge and experiences with each other and to learn from each other. This leads to collaborative learning and a two-directional exchange of ideas.

Organizational learning is the subsequent stage of the learning community cycle and involves assembling and organizing knowledge and experiences relative to specific orientations and cultural values. Analogous to individualized learning, organizational learning occurs and grows at different rates. In addition, organization learning aims to adapt to changing environments, keep up with other organizations, and increase efficiency (Dodgson, 1993). In 1993, Argote concluded that managers in manufacturing plants experienced and applied organizational learning while discovering methods to improve the organization's structure, use of technology, and technological efficiency and to enhance the organization's strengths and unique characteristics (Argote, 1999).

Inter-organizational learning is the final phase of the cycle. Analogous to the two-directional exchange of ideas among individuals in group learning, the two-directional exchange of ideas occurs among organizations in inter-organizational learning (Tucker *et al.*, 2007). First, an organization can adapt successful practices, such as production efficiency, effective communication with the staff, and an amiable working environment, from another organization. Second, an organization can revise another organization's idea and transform it into a different one.

7.5 End of Chapter Summary

It is critical for teachers and faculty members to adapt to their new roles in the teaching and learning environment. This prepares them to guide their students to adapt smoothly to the new learning environment and navigate them to reaching the expected learning outcomes. This is analogous to adaptation to climbing and discovering new alpine landscapes at altitudes higher than before. In addition, it is crucial to consider combinations of roles to reach the expected learning outcomes. For instance, blending social and managerial roles is the most vital combination, as it describes the quality and character of the online course. A combination of the pedagogical and technical roles is also essential, as the new pedagogical innovations and teaching practices cannot be implemented without the necessary technological resources.

7.6 Further Thoughts

1. In Sections 7.1 and 7.2, we discussed the characteristics of the pedagogical role and the social role. Compare the similarities and contrasts between the pedagogical and social roles. What do these two roles have in common?
2. In Section 7.1, we discussed the fundamentals of the pedagogical role. Within the pedagogical role, we compared the similarities and contrasts between the cognitive and facilitation roles. What do these two roles have in common?
3. In Section 7.4.2, we discussed the rudiments of organizational learning. What do individualized learning and organizational learning have in common? What do group learning and cross-organizational learning have in common?
4. In Section 7.4, we combined the facilitation role with the social and managerial roles. How do the social and managerial roles interact to implement the goals of the facilitation role effectively? What is the percentage of responsibilities of the social and managerial roles?

Chapter 8

Emotional Intelligence and Cognition

The following quotes reveal some of the decision-making and emotional intelligence fundamentals:

> "A good decision is based on knowledge and not on numbers." — Plato.

> "When making a decision of minor importance, I have always found it advantageous to consider all the pros and cons." — Sigmund Freud.

> "Decision making is easy when your values are clear." — Roy Disney.

Emotional intelligence is defined as the ability to describe and understand others' emotions and to handle interpersonal relationships and conflicts smoothly and empathetically. Emotional intelligence leads to rational thinking, making the right choices, and managing and adjusting the emotions in order to acclimate to the circumstance(s) and achieve the goals (Goleman, 1995).

Emotional intelligence is an essential source that leads to flexibility, tolerance, effective decision-making, leadership, and innovation (Epstein, 1998). The following diagram in Figure 8.1 outlines the four primary domains of emotional intelligence.

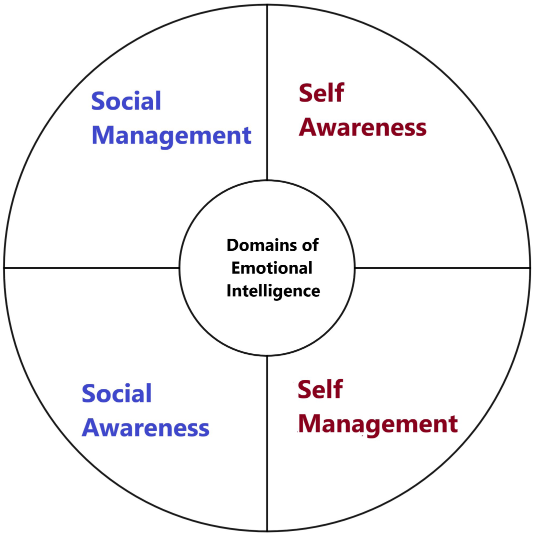


Figure 8.1. The Domains of emotional intelligence.

Self-awareness combines recognition and personal competence. Self-awareness emphasizes the importance of self-confidence, recognizing the consequences of behavior, awareness, understanding of emotional states (happiness, sadness, fear, anger, surprise, and disgust), and others' influence on emotional states.

Self-management combines regulation and personal competence. Self-management reveals the fundamentals of emotional regulation and focuses on managing and minimizing negative and disruptive emotions. It also aims to achieve goals while encountering obstacles, while indicating the importance of flexibility and the use of alternative methods and resources.

Social awareness combines recognition and social competence. Social awareness emphasizes the essence of flexibility to feedback and recommendations. What do others say and do?

Social management combines regulation and social competence. Social management aims to establish an amiable and trustworthy relations, effective two-directional communication, and managing interactions and emotions with other people.

8.1 Emotional Regulation and Techniques

Emotional regulation is interpreted as "the processes by influencing which emotions we have, when we have them, and how we experience and express them." Emotional regulation guides you in managing and regulating your emotions to respond effectively to challenging circumstances without overreacting. This is analogous to the quote "It is not what happens, but how you react" by William Clinton.

8.1.1 *The iceberg model*

The iceberg model is an essential soft system thinking tool that focuses on deductive reasoning and on noticing and detecting details that are not easily noticeable by everyone, hence finding the primary source or root of the problem. In medicine, this includes diagnosing the disease; in education, this includes detecting the reasons for many students failing a specific course, the source of inflation in economics; etc. Determining the sources and roots of such problems leads to asking the right questions that detect specific details. More details on asking the right questions will be addressed in Section 8.2.2.

The iceberg model presented in Figure 3.9 is a visual scheme of various components of emotional intelligence. This model aids individuals in revealing the essence of emotional intelligence and how it influences their behavior, relationships, and overall success in both personal and professional objectives. Analogous to the iceberg model, the components in Figure 3.9 are either concrete (visible) or emotional (hidden). The following diagram in Figure 8.2 outlines the four fundamental visible components of emotional intelligence (Goleman, 1995).

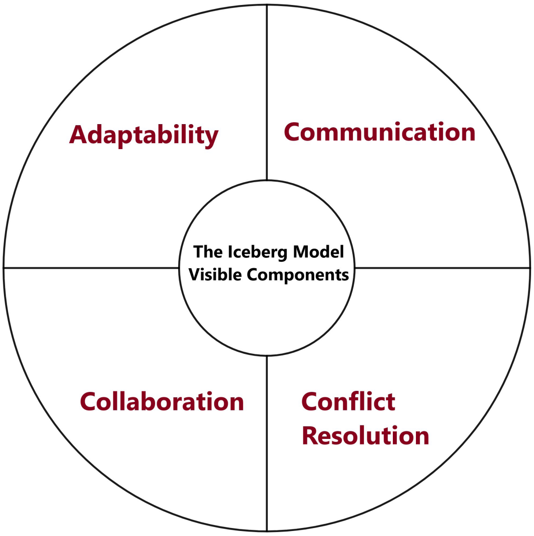


Figure 8.2. The iceberg model: Visible components.

Figure 8.2 portrays the noticeable aspects of emotional intelligence that others can easily see and interpret (Goleman, 1995; Mayer, 2002).

Communication is the ability to effectively convey and receive information, ideas, and emotions (Goleman, 1995). This includes effective two-directional communication and the exchange of ideas.
Conflict resolution is the ability to manage and resolve disagreements or disputes constructively (Goleman, 1995). Effective conflict resolution refers to applying flexibility, divergent thinking, emergent learning, and cross-cultural comparisons and contrasts.
Collaboration is the ability to work cooperatively and effectively with others toward a shared goal (Goleman, 1995). Collaboration reveals the fundamentals of organizational learning, such as collaborative learning, group learning, and inter-organizational learning.
Adaptability is the ability to adjust and respond effectively and positively to changing circumstances or environments (Goleman, 1995). Adaptability unfolds the principles of social role, emergent

learning, complexity, diversity, and cross-disciplinary and cross-cultural exchange of ideas. Adaptability also directs you toward detecting mistakes and missing fragments, making revisions, and providing guided and constructive feedback.

The following diagram in Figure 8.3 outlines the five primary invisible components of emotional intelligence (Goleman, 1995).

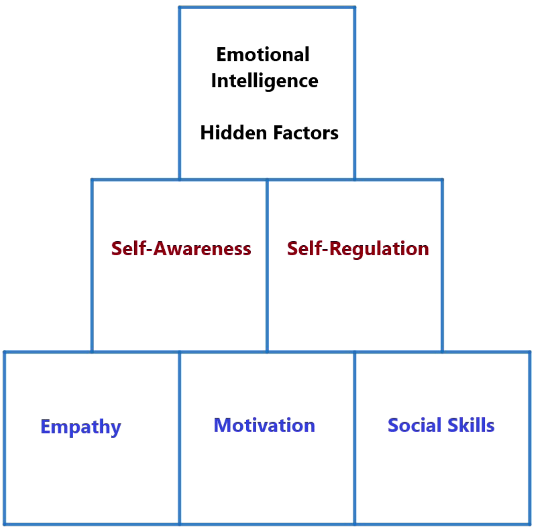


Figure 8.3. The iceberg model: Invisible components.

Figure 8.3 presents the underlying aspects of emotional intelligence that are not immediately apparent but play a crucial role in shaping the visible behaviors and skills (Goleman, 1995; Mayer *et al.*, 2002).

Self-awareness is the recognition and interpretation of your own emotions, strengths, weaknesses, and motivations (Goleman, 1995). Self-awareness also emphasizes the principles of self-assessment, such as self-knowledge, self-verification, self-enhancement, and self-esteem (Sedikides, 1993).

Self-regulation focuses on managing and regulating your emotions, impulses, and reactions in various situations (Goleman, 1995). Self-regulation also regulates spontaneous and negative reactions.

In Greek, **empathy** is defined as passion or physical affection and aims to understand, feel, and share the emotions and perspectives of others (Goleman, 1995). Examples of empathy include cognitive empathy, emotional (or affective) empathy, somatic empathy, and spiritual empathy.

Motivation can be interpreted as the intrinsic drive to accomplish goals, improve, and persevere in challenging situations (Goleman, 1995). Motivation can originate as an individual stimulation or from internal or external feedback.

Social skills constitute the ability to establish and retain positive relationships with others, navigate in various social situations, and influence the emotions and behaviors of others (Goleman, 1995).

Understanding and developing the hidden factors of the iceberg model presents individuals with opportunities to enhance their interpretation of emotional intelligence and their visible behaviors and skills. This, in turn, can lead to better personal and professional outcomes, including improved relationships, greater well-being, and more productive outcomes.

The iceberg model aids individuals in enhancing their understanding of emotional intelligence through self-reflection, seeking feedback from others, participating in training or coaching, and applying their emotional intelligence skills together with emergent learning in various situations.

8.1.2 *Internal vs. external feedback (influences)*

Section 6.3 presented the principals of primal leadership and resonance leadership, which outline the essential characteristics of emotional intelligence and emotional regulation. In fact, primal leadership and resonance leadership also highlight the essence of adaptation, which emphasizes the essence of two-directional exchange of ideas, diversity, tolerance, equity, inclusion, flexibility, and feedback.

Internal feedback is feedback that arises from within the organization and culture. This includes, for instance, feedback from within the same department, discipline, research group, university, or culture. On the other hand, **external feedback** can originate from a different department, discipline, or culture. External feedback can emerge as cross-disciplinary and cross-cultural and can often originate from diversity and complexity, as well as from education and experiential contrasts. Internal feedback can be interpreted as domestic feedback, while external feedback can be interpreted as foreign feedback. The following Venn diagram in Figure 8.4 sketches the scheme of internal and external feedback and their combinations.

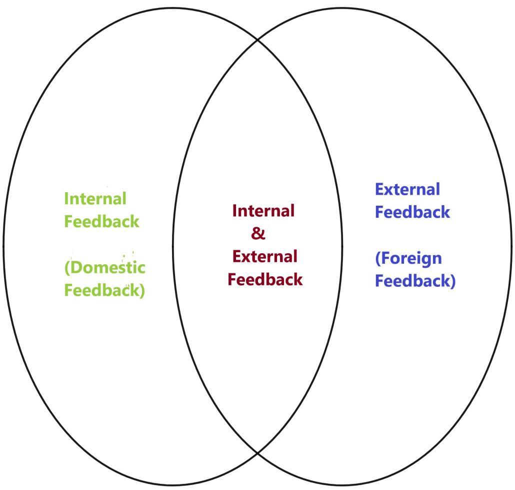


Figure 8.4. Internal & external feedback: Venn diagram.

Figure 8.4 then unfolds the following questions regarding internal and external feedback:

What are the common traits between internal and external feedback? What are the common cross-disciplinary, cross-cultural, educational, and experiential characteristics? What common benefits do they welcome?
What are the notable contrasts between internal and external feedback? What cross-disciplinary, cross-cultural, educational, and experiential contrasts arise? How do you interpret these contrasts, and how do you implement them effectively?

Figure 8.5 reveals the answers to these questions and presents the feedback cycle.

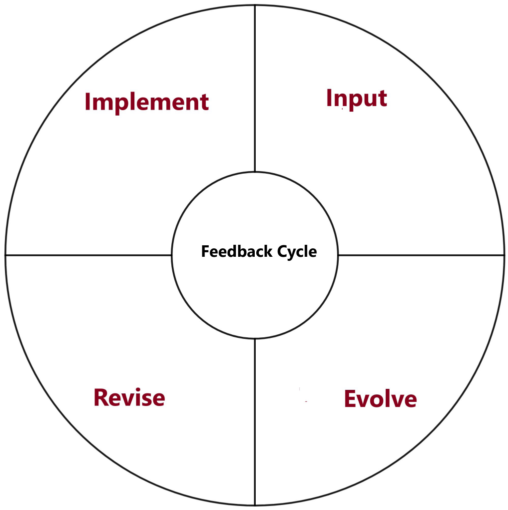


Figure 8.5. The feedback cycle.

Your colleagues' **input** is the first stage of the feedback cycle. Input can be either internal or external. These include suggestions, recommendations, and new ideas, practices, and orientations.
Evolution is the next phase of the feedback cycle. It focuses on detecting specific problems, missing fragments, and the sources and roots of the problems by applying the principles of the iceberg model discussed in Sections 3.2.3 and 8.1.1.
Revision is the subsequent step in the feedback cycle. It explores creative and innovative solutions to designated problems and fills in the missing gaps by applying concrete representation and abstract thinking, convergent and divergent thinking, continuous and emergent learning, and soft and hard tools discussed in Sections 5.2–5.5.
Implementation is the final phase of the feedback cycle and outlines and summarizes the cycle's scheme and outcomes. First, implementation involves analyzing the comparisons of the outcomes

before and after revisions. Second, it reveals the fundamentals of self-assessment and peer-assessment.

Implementation and accurate assessment of the cycle's outcomes is critical prior to the next iteration of the feedback cycle. These two guide one to additional feedback and recommendations. The aim is to produce better outcomes during each iteration of the feedback cycle. Additional attributes of feedback and assessment will be discussed in Section 8.1.3.

The following stocks and flows diagram in Figure 8.6 outlines and summarizes the rudiments of feedback presented in Figures 8.4 and 8.5.

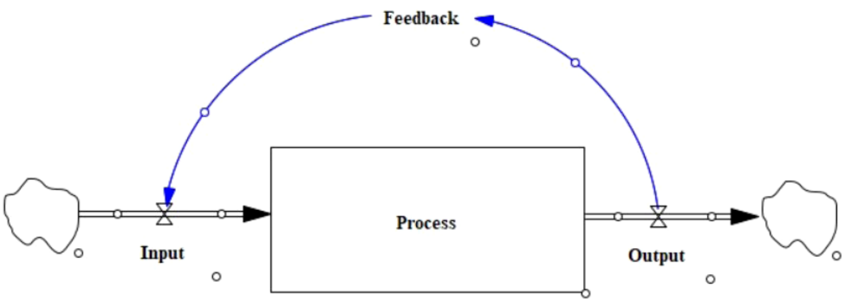


Figure 8.6. Stocks & flows feedback diagram.

Note that in Figure 8.6, the input presents the inflow rate and the output presents the outflow rate, and Eq. (3.1) describes the difference between the input and output rates.

8.1.3 *Additional attributes of feedback and assessment*

The feedback cycle assembled and described in Figures 8.4 and 8.5 is oriented to recommend adjustments and revisions. In particular, necessary adjustments and revisions naturally emerge after accurately assessing action, behavior, and output. In fact, an iterated feedback cycle becomes a critical component in various contexts, such as learning, communication, and complex systems, as it facilitates adaptation, growth, and performance enhancement (Hattie and Timperley, 2007). An iterated feedback cycle presents positive feedback, negative feedback, and forward feedback, while implementing self-assessment, peer assessment, and external assessment.

Positive feedback, or reinforcing feedback, highlights the strengths and achievements and recommends minor adjustments and revisions. It promotes additional stimulation to accomplish further and more challenging achievements (Hattie and Timperley, 2007).

Negative feedback, or corrective feedback, detects and emphasizes serious problems and missing fragments that require serious adjustments and revisions in order to achieve the desired goals. It also aims to correct menacing consequences that result from problematic behaviors, actions, and outcomes by providing accurate, constructive, and guided critiques and feedback (Kluger and DeNisi, 1996).

Feed-forward, or forward feedback, focuses on future performance by providing specific, actionable, and positive suggestions for improvement. It stimulates the expansion of comfort zones through open, two-directional communication, collaboration, and learning. In the meantime, forward feedback emphasizes the essential future revisions in order to achieve stronger outcomes, instead of repeating previous weaker and unsuccessful outcomes and mistakes (Bennis and Goldsmith, 2003).

Positive feedback, negative feedback, and feed-forward and their combinations can foster continuous, individualized, collaborative, and organizational learning and stimulate future revisions to generate stronger and more effective outcomes. By understanding the fundamentals and applying them effectively, individuals and organizations can achieve more productive performance and results. Positive feedback, negative feedback, and feed-forward also apply to implement accurate and precise self-assessment, peer assessment, and external assessment at the end of the feedback cycle.

Self-assessment, or self-evaluation, is the process of providing your own individual feedback by detecting mistakes, sources of mistakes, and missing fragments. Effective self-assessment focuses on self-reflection and self-evaluation to identify strengths, weaknesses, and future revisions for self-enhancement (Falchikov and Boud, 1989).

Peer assessment is feedback from peers and colleagues with similar educational and experiential backgrounds. In fact, peer assessment offers alternative perspectives and can help identify areas for improvement or validate strengths (Topping, 1998). Peer assessment also stimulates numerous metacognitive and attitude perspectives. Peer assessment unfolds opportunities to gain beneficial feedback that supervisors may not necessarily provide and for a two-directional exchange of ideas among your peers and colleagues. What new practices can you adapt from your peers and colleagues?

External assessment is feedback from experienced supervisors, mentors, or other external sources with different educational and experiential backgrounds. External assessment aims to provide objective evaluations and guidance to enhance personal and professional growth (London and Smither, 2002). External assessment includes diagnostic, formative, and summative assessments.

8.2 Ambitions and Aspirations

In Sections 5.2–5.4, we examined the similarities and contrasts between concrete representation and abstract thinking, convergent and divergent thinking, and continuous and emergent learning. Sections 8.2.1–8.2.3 will delve into deeper characteristics that examine the similarities and contrasts between simplicity and complexity, internal and external influences, and fixed and expanded comfort zones.

8.2.1 *Emotional vs. rational (practical) thinking*

Rational and emotional thinking are two key components of human cognition that play significant roles in decision-making, problem-solving, and overall mental well-being. While these two modes of thinking often coexist and interact, they present their unique characteristics and influences on human behavior (Epstein, 1994).

Rational thinking is an analytic process that focuses on reason and drawing sensible conclusions from facts, logic, and data. Thinking is said to be rational when thoughts are based on logic and facts.

Rational thinking can often apply the fundamentals of data analysis and divergent thinking by deciphering, sorting, and comparing facts and data. It leads to accurate and precise comparison analysis by examining the similarities and contrasts between different facts and categories of data.

Rational thinking, or logical thinking, is a cognitive process that relies on reasoning, logic, and critical thinking skills to analyze and evaluate information, make decisions, and solve problems (Stanovich and West, 2000). Rational thinking involves a systematic and structured approach to processing information, considering evidence, and drawing conclusions based on objective evaluation. This type of thinking is essential for tasks that require objective evaluation, logical consistency, and a focus on details and facts.

Emotional thinking, on the other hand, is a cognitive process that involves the integration of emotions, feelings, and intuition in decision-making and problem-solving (Damasio and Damasio, 1994). It is often characterized by its reliance on strong feelings and emotions, personal values, and subjective experiences. This type of thinking is crucial for tasks that involve empathy, compassion, motivation, and understanding human emotions.

However, the conclusions of emotional thinking may not necessarily match the empirical evidence. Emotional thinking leads to an "emotional truth," which may not coincide with the "perceptional truth" (de Sousa and Morton, 2002). This type of thinking can naturally arise from personal experiences that reflect on specific circumstances that occurred. These experiences may be outdated and not necessarily compatible with the current phenomena and hence can lead to incorrect interpretations and mistakes.

Figure 8.7 traces a Venn diagram representation of the **three minds model**:

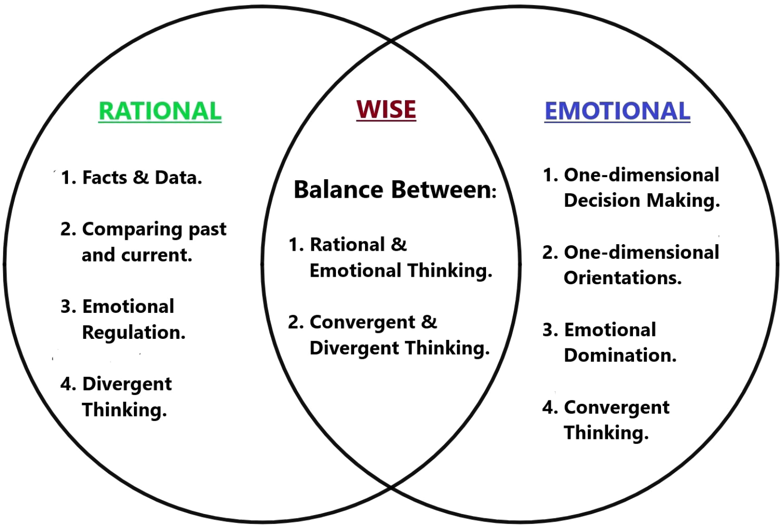


Figure 8.7. The three minds model.

The relationship between rational and emotional thinking is quite challenging and complex. Depending on the context and the individual's cognitive preferences, these two modes of thinking can be complementary or conflicting (Epstein, 1994). As outlined in Figure 8.7, some circumstances may require a balance of both rational and emotional thinking to make the most effective decision, while others may require either only a rational or an emotional approach.

The causal loop diagram in Figure 8.8 outlines and summarizes the relationships between the concepts presented in Figure 8.7.

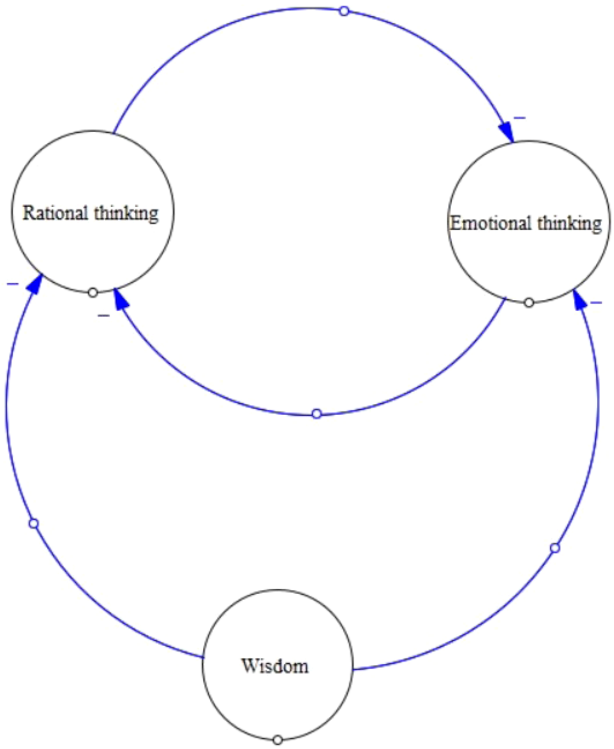


Figure 8.8. Causal loop diagram: Emotional vs. rational thinking.

Figure 8.8, together with Figure 8.7, traces the following characteristics:

- Dominating emotions and excessive emotional thinking interfere with rational thinking. This may lead an individual to make decisions based on emotions rather than objective reasoning:

$$\text{Emotional Thinking(ET)} \longrightarrow \text{Rational Thinking(RT)}: \text{Negative}(-).$$

- Dominating rational thinking suppresses potentially creative emotional thoughts. This may result in an individual overlooking the emotional (creative and innovative) aspects of a situation and making decisions that lack empathy or emotional understanding:

$$\begin{aligned}\text{Rational Thinking(RT)} \;\longrightarrow\; & \text{Emotional Thinking(ET)} : \\ & \text{Negative}(-).\end{aligned}$$

- As wisdom detects a strong focus on emotional thinking, it helps an individual regulate his/her emotions and shift his/her priorities toward rational thinking to achieve and retain a better balance:

$$\text{Wisdom(W)} \;\longrightarrow\; \text{Emotional Thinking(ET)} : \text{Negative}(-).$$

- As wisdom detects a strong orientation toward rational thinking, it helps individuals regulate his/her emotions and shift his/her emotional toward emotional (creative and innovative) thinking to achieve and retain a better balance:

$$\text{Wisdom(W)} \;\longrightarrow\; \text{Rational Thinking(RT)} : \text{Negative}(-).$$

8.2.2 *Good questions vs. right questions*

The following quote by W. Edwards Deming unfolds the essence of asking the right questions: "If you do not know how to ask the right question, you discover nothing."

What are the differences between good questions and right questions? Which questions ignite curiosity? Which questions stimulate collaborative learning and experiential learning? Which questions write a welcoming selling story? Which questions lead to reaching the expected outcomes? Figure 8.9 outlines the scheme and reveals the answers to these questions.

Figure 8.9 presents the following definitions, similarities, and contrasts between good questions and right questions.

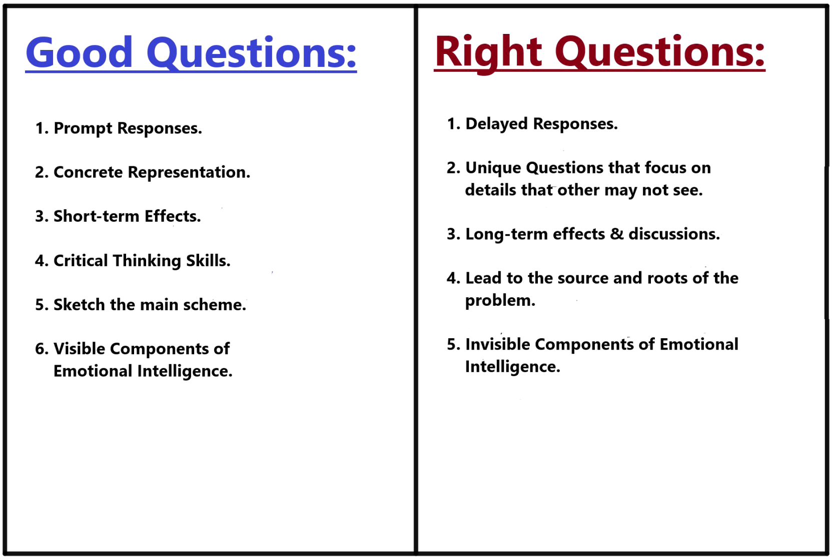


Figure 8.9. Good questions vs. right questions.

Good questions are questions that seek clarification, encourage critical thinking, and navigate to deeper understanding of a concept or theme. Good questions can be open-ended or specific questions that stimulate new thoughts and discussions. Good questions may lead to more questions or require further research, but they ultimately enhance knowledge and understanding. The following guidelines present a recommended systematic design for asking good questions:

- Be curious and open-minded, and approach the theme with genuine curiosity and a desire to learn.
- Seek clarification by asking questions that clarify concepts, definitions, and ideas.
- Encourage critical thinking by framing questions to challenge assumptions, explore different perspectives, and analyze underlying reasons.

Examples of good questions include:

- "How do complex systems adapt to changing conditions?"
- "What factors contribute to the success of a start-up?"
- "How does emotional intelligence influence workplace success?" — Goleman (1995).
- "What role does technology play in improving healthcare outcomes?" — Topol (2019).

Right questions are questions that specifically target the root cause or fundamental nature of a problem or circumstance. These questions are designed to be highly relevant, and their answers may lead to actionable insights or effective solutions. In comparison to good questions, right questions are often more challenging to identify and ask. Right questions can be more powerful tools for critical thinking, problem-solving, and systems thinking. The following guidelines present a recommended systematic design for asking the right questions:

- Identify the core issue and focus on the root cause or essential aspect of the problem or circumstance.
- Be specific and relevant, and ask questions that are directly related to the issue at hand and have practical implications.
- Seek actionable insights, and frame questions that lead to potential solutions or strategies for improvement.

Examples of right questions include:

- "What are the underlying patterns and structures that drive the behavior of a complex system?" — Meadows (2008).
- "What is the most critical factor that determines the success or failure of a start-up, and how can we address it?" — Ries (2011).
- "How can organizations effectively develop and leverage emotional intelligence to improve workplace performance?" — Goleman (1995).
- "What are the key barriers to adopting new healthcare technologies, and how can we overcome them?" — Topol (2019).

The causal loop diagram in Figure 8.10 outlines and compares the similarities and contrasts between the relationships and between the concepts presented in Figure 8.9.

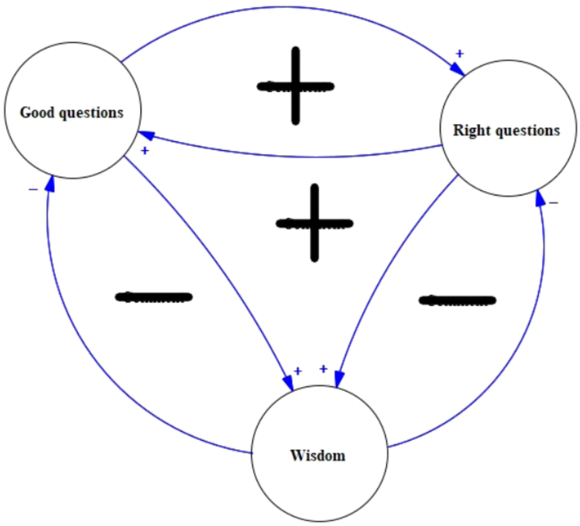


Figure 8.10. Causal loop diagram: Good questions vs. right questions.

First, note that the more good questions (GQs) are asked, the more they help in identifying relevant aspects of a problem or circumstance. This, in turn, assists in formulating the right questions (RQs) that generate accurate and reliable information. Similarly, asking the right questions and obtaining precise information enhances the understanding of context and ethical considerations. This trains an individual to ask more accurate good questions. This mutual reinforcement formulates a positive feedback loop presented in Figure 8.10, together with the outlined fundamentals presented in Figure 8.9.

Second, observe that Figure 8.10 describes the reinforcing loop between GQs, RQs, and wisdom (W). In fact, asking both good and right questions presents opportunities to effectively integrate information, context, and values. Then, these guide us to effectively develop wisdom (W). As wisdom grows, an individual gains more skills and experiences in formulating both good and right questions in various situations. This continuous growth and improvement contribute to better decision-making and problem-solving capabilities, hence reinforcing the enhancement of wisdom.

As a special case of the stocks and flows diagram in Figure 3.8 in Section 3.2.2, Figure 8.11 presents the stocks and flows diagram by linking good and right questions together with developed wisdom.

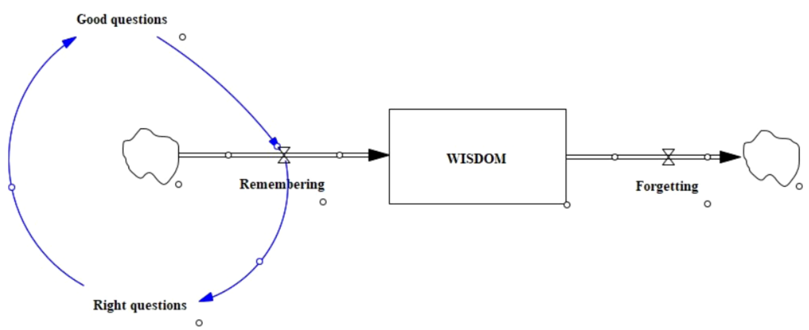


Figure 8.11. Stocks & flows diagram: Asking the right questions.

In Figure 8.11, wisdom is represented as a stock, which represents the experience and intuitions that an individual gained and retained. The inflow to the stock is the acquisition of new knowledge, which is the rate at which a person learns new information by reading, studying, or encountering new experiences. The outflow from the stock is forgetting, which is the rate at which knowledge is lost over time.

8.2.3 *Easy choices vs. right choices*

The decision-making process involves various factors that can influence individuals or organizations when considering an easy choice or the right choice. Such factors include personal values, societal norms (Lerner and Tetlock, 2003), financial constraints, time pressures, or institutional frameworks (Simon, 1997).

Hard choices, or tough choices, emerge when a specific question does not have a unique answer or has no answers at all. This type of choice requires a very thorough analysis, from which you can frequently encounter substantial risks that lead to sacrifices and losses. Which opportunities are you giving up? What will the rewards be?

It is critical to differentiate between easy choices and right choices during the decision-making process. Easy choices typically offer immediate benefits, require less effort or resources, and may focus on short-term goals (Schwartz, 2004). On the other hand, right choices often prioritize long-term benefits, involve more effort and resources, and align with ethical principles or broader objectives (Kidder, 2009).

Making choices or decisions involves considering potential consequences and trade-offs. The short-term benefits of an easy choice might come at the cost of long-term impacts or risks to stakeholders, the environment, or the overall system. Conversely, right choices may require sacrificing short-term gains for long-term benefits and ethical considerations. Real-world examples can illustrate the differences between easy choices and right choices. For instance, making a choice between cutting costs in a company by outsourcing jobs (an easy choice for short-term profits) and investing in employee development to ensure long-term success and ethical business practices (a right choice) (Pfeffer, 2010).

Motivations and incentives can stimulate individuals or organizations to make either easy or right choices. External factors, such as financial rewards or social pressures (Ryan and Deci, 2000), and internal factors, such as personal beliefs or ethical considerations (Kohlberg, 1981), can influence decision-making. Are right choices easy choices? This strongly depends on an individual's value orientations, experiences, and educational and cultural backgrounds. What are easy choices and right choices? How do easy choices and right choices relate to emotional and rational thinking? Which choice paves the path to achieving the expected outcomes? Figure 8.12 presents the virtues of easy and right choices and the similarities and contrasts between easy and right choices.

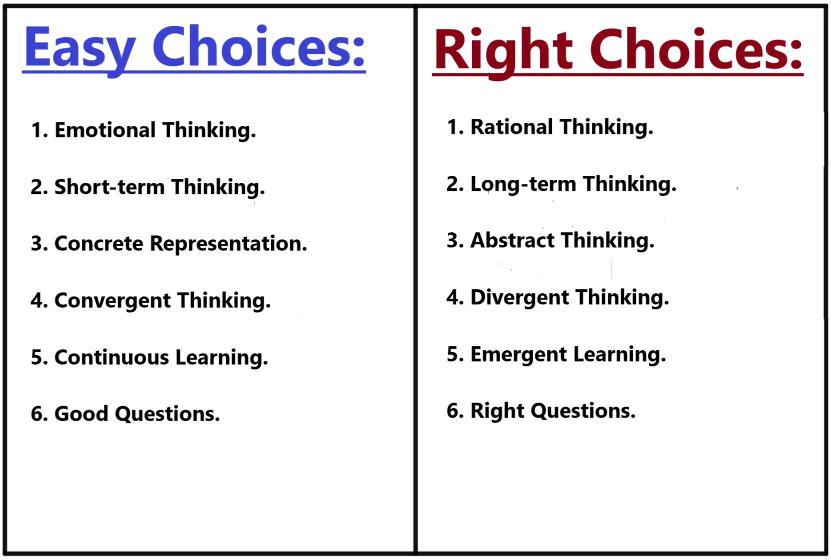


Figure 8.12. Easy choices vs. right choices.

Easy choices can be interpreted as choices based on a recommended path, experiences and intuitions within your comfort zone, and internal influences. These are often quick choices that require a very meager comparison of similarities and contrasts and a short process. Easy choices relate to factors that resemble the visible components of the iceberg model.

Right choices can be interpreted as choices that lead to the desired outcomes, positive consequences, and long-term effects. Right choices are often made based on conclusions drawn from numerous observations that analyze data and facts. Comparing similarities and contrasts between concepts, themes, data, facts, disciplines, and cultures can be frequently encountered while attempting to make the right choices.

Numerous uncertainties can arise while seeking to make the right choice. These uncertainties emerge due to diversity, complexity, external influences, and risk. These factors resemble the invisible components of the iceberg model and navigate to enhancing cognitive skills, comparison skills, and creative thinking beyond your comfort zones, experiences, and intuitions. Making the right choices will often require asking the right questions. Which choice will navigate you to the best outcome? Which choice will guide you to the most efficient outcome? Which choice will minimize the cost and maximize the profit?

Making the right choices significantly enhances personal and organizational growth and fosters learning, adaptability, and the development of a strong ethical foundation (Senge, 2006). Consistently making the right choices can lead to increased trust and a positive reputation.

The causal loop diagram in Figure 8.13 outlines and compares the similarities and contrasts between the relationships and between the concepts presented in Figure 8.12.

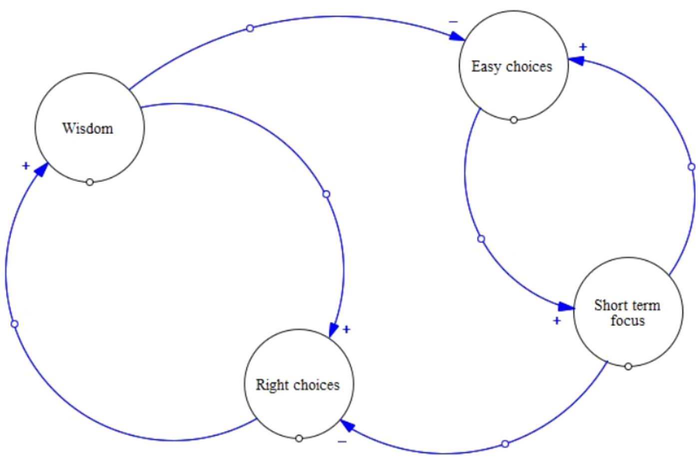


Figure 8.13. Causal loop diagram: Easy vs. right choices.

Figure 8.13 sketches the reinforcing and balancing loops and their connections.

The **reinforcing loop** emphasizes the relationship between easy choices and short-term focus. In particular, the reinforcing loop indicates that the two variables have a positive influence on each other and hence create a cycle that strengthens over time. The reinforcing loop underlines that making an easy choice increases the short-term focus and hence leads to making more easy choices. This cycle can hinder people from considering long-term benefits and making more informed decisions.

The **balancing loop** focuses on the relationship between right choices and wisdom. In particular, the balancing loop emphasizes that the two variables also have a positive influence on each other, hence balancing and stabilizing the system. The balancing loop indicates that making a right choice develops and enhances wisdom, which leads to making more right choices. This balancing loop helps counteract the reinforcing loop and promotes more sustainable and beneficial decision-making in the long run.

Note that Figure 8.13 also shows that short-term focus negatively influences right choices, while wisdom negatively influences easy choices. This connection between the loops highlights the interplay between the variables and emphasizes the importance of promoting wisdom to shift the balance toward making the right choices for long-term benefits.

8.3 End of Chapter Summary

Emotional intelligence is an essential skill to understand and apply in order to successfully adapt to unexpected and rapidly changing circumstances. Emotional intelligence emphasizes abstract thinking, divergent thinking, and emergent learning. These are vital tools to apply while determining the roots of a challenging problem and attempting to solve it that go beyond your comfort zones, experiences, and intuitions. Emotional intelligence stimulates rational thinking that promotes asking the right questions and making the right choices. These form a solid base that paves the path to creative and innovative thinking.

8.4 Further Thoughts

1. In Section 8.1.2, we discussed internal and external feedback. How do you distinguish the contrasts between them? Which feedback is more influential? How do you balance the two types of feedback?

2. In Section 8.2, we discussed emotional thinking vs. rational thinking, good questions vs.right questions, and easy choices vs. right choices. In which specific order should these be implemented when encountering a challenging problem or circumstance? Can these be assembled as an iterative cycle?
3. In Section 8.2.1, we discussed the rudiments of emotional thinking, rational thinking, and the three minds model. How do these rudiments relate with the fundamentals of systems thinking? In particular, what are the connections between emotional perception, rational analysis, and systems thinking?
4. In Section 8.2.2, we discussed good questions and right questions. We provided examples when asking the right questions is essential. In which professions is asking the right questions is critical? Analogous to the three minds model in Figure 8.7, is there an overlap between asking good questions and right questions?
5. In Section 8.2.3, we discussed the contrasts between easy choices and right choices. Are right choices made with your mind or with your instincts? Can right choices be easy choices? Analogous to the three minds model in Figure 8.7, is there an overlap between easy choices and right choices?
6. In Section 8.2.3, we examined the virtues of easy choices and right choices. Can easy choices be comprehended as deductively-oriented and right choices be comprehended as inductively-oriented?

Chapter 9

Creativity, Innovations and Dynamics

The following quotes reveal the essential attributes of creativity, leadership, innovation, entrepreneurship, and start-ups:

> "Don't worry about failure; you only have to be right once. Every failure is just a trial until you succeed." Drew Houston, co-Founder and CEO of Dropbox.
>
> "Your most unhappy customers are your greatest source of learning. Mistakes and losses are way towards gaining ideas and growing." Bill Gates, founder of Microsoft.

In Section 1.5, we defined **creativity** as the imagination of original and unique ideas and the tendency to generate and recognize ideas, alternatives, or possibilities that may become beneficial in solving challenging problems. Creativity requires thinking and imagination beyond our experiences and intuitions and often coincides with abstract thinking, divergent thinking, emergent learning, and asking the right questions.

In Section 1.2.2 and in Chapter 6, we defined **leadership** as providing influential guidance to followers. Leadership can be interpreted as the ability to impact and navigate individuals, teams, or organizations to accomplish a common and ethical task.

In Section 1.5, we defined **innovation** as an orientation to design new ideas and alternatives to solve specific problems. Innovation also expands learning horizons, promotes new ideas and practices, and often requires thinking beyond the boundaries of your comfort zones, experiences, and intuitions and hence leads to the fundamentals of entrepreneurship and risk management.

Entrepreneurship is defined as the art and science of designing a business and generating economic value. Entrepreneurship also involves risk taking beyond your comfort zones, experiences, and intuitions. Entrepreneurship can be interpreted as a source of innovative, unique, and beneficial ideas and outcomes.

A **start-up** is an innovation or project initiated by an entrepreneur to seek and design a scalable business model with goals to expand beyond the solo founder (Katila *et al.*, 2012). A start-up can be considered as the first implementation step of an innovation.

The rudiments of creativity, leadership, innovation, entrepreneurship, and start-ups can be extended to designing new courses, new seminars, cross-disciplinary and cross-cultural collaborations, and educational reforms. These rudiments then guide you to divergent thinking, rational thinking, asking the right questions, and understanding diversity and complexity.

The diagram in Figure 9.1 outlines the causal loop scheme of creativity, leadership, innovation, entrepreneurship, and start-ups.

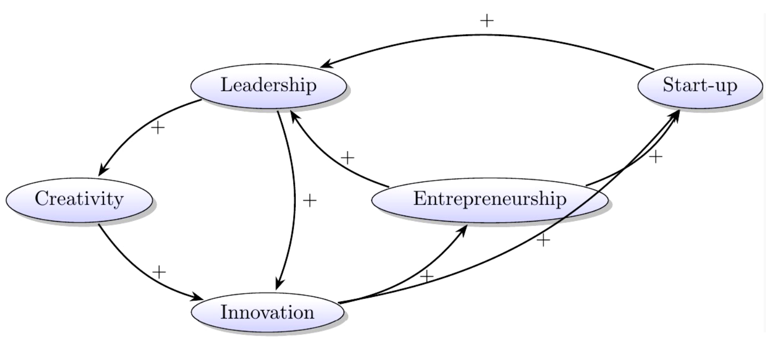


Figure 9.1. Causal loop scheme of creativity, innovations, and leadership.

First, note that leadership fosters creativity. Effective leaders inspire team members to think creatively beyond their comfort zones. The "+" sign on the connecting arrow underlines that an increase in leadership tends to promote an increase in creativity.

Creativity stimulates innovation. When teams are encouraged to be creative, they are more likely to develop innovative ideas and solutions. The "+" sign indicates that more creativity leads to more innovation.

Innovation is a crucial aspect of entrepreneurship, as entrepreneurs take these innovative ideas and design viable business strategies and models. The "+" sign emphasizes that more innovation tends to stimulate more entrepreneurship.

Entrepreneurs are the driving forces behind the design of start-ups. Their goals are to turn innovative ideas into a business, which leads to the establishment of a start-up. The "+" sign indicates that more entrepreneurship tends to result in more start-ups.

Start-ups require effective leadership to enhance their growth and development. The "+" sign symbolizes that with the growth of a start-up, the need for leadership also increases.

Successful start-ups require a high degree of innovation. In particular, innovation aids in the accurate understanding of competitors and enhances growth. The "+" sign indicates that more innovation leads to further development of start-ups.

Entrepreneurs guide their start-ups through numerous challenges and often encounter critical decisions. The "+" sign emphasizes that as entrepreneurship increases, the need for leadership also increases.

Throughout this chapter, we apply the following tools to systematically and accurately understand the design and expansion of start-ups:

- **Causal loop diagrams** are beneficial tools for designing and outlining the relationships between the variables and feedback loops within a system. In particular, feedback loops aid in visualizing the interdependencies and interactions within the system, which can lead to insights about potential leverage points and areas for intervention.
- The **system dynamics modeling** approach involves the design of computer simulations of systems to predict their behavior over time. This approach guides you to understanding the potential long-term impacts of different interventions and decisions.
- The **brainstorming** technique generates innovative solutions to problems within a system. Examples of such techniques include

classic brainstorming, mind maps, the Six Thinking Hats method, or SCAMPER (substitute, combine, adapt, modify, put to another use, eliminate, and reverse).

The **scenario planning** technique envisions different future scenarios based on various factors and variables. This technique focuses on divergent thinking, rational thinking, asking the right questions, and making the right choices. As a consequence, this can be a particularly useful technique in systems thinking as it encourages long-term thinking and considering multiple possible outcomes.

The **stakeholder analysis and empathy mapping** techniques guide one to understanding the perspectives of different actors within a system. These are crucial techniques in developing solutions that meet the needs and considerations of stakeholders.

9.1 Innovations and Adaptive Dynamics

Figure 9.5 sketches a systematic scheme for designing an innovation. The design of an innovation leads to creative problem-solving techniques by asking the right questions that detect mistakes, problems, their roots and sources, and missing fragments. How is your solution different and better than your competitors' and what new and unique benefits will it bring? Section 9.1.1 reveals the answers to these questions.

9.1.1 *Stimuli, feedback, and revisions*

Revisions of stories, ideas, or innovations are essential, as your initial draft will often have missing ingredients and as your colleagues and friends will see details that you may not have thought of. It is therefore essential to be aware of minuscule details and be flexible enough to make any necessary revisions while designing your story, idea, or innovation. You will rarely revise your initial draft only once. It may require several revisions.

For instance, when revising an innovation in the context of start-ups, it is crucial to understand the relationships and dependencies among the components within a system (Meadows, 2008). Revisions are beneficial as they can help identify problematic areas that require revisions and prevent unintended consequences. A start-up may develop an innovative business model that relies on technology, customer behavior, market trends, and regulatory frameworks. Understanding the interconnections between these components can reveal opportunities for refining innovation and help anticipate potential challenges, such as technology adoption barriers or regulatory constraints (Blank, 2013).

System dynamics modeling techniques can help simulate the impact of a revised innovation on a start-up over time. This involves detecting potential unintended consequences, bottlenecks, and opportunities for improvement (Sterman, 2000). In the case of a start-up, system dynamics models can be beneficial in examining the interactions between product development, customer adoption, revenue generation, and other critical factors. Such models can help entrepreneurs and investors make more informed decisions about how to support the growth of the start-up and mitigate potential risks (Forrester, 1961).

Positive and negative feedback loops play a significant role in the revision process of start-up innovations (Sterman, 2000). Positive feedback loops occur when a change in one component in a system leads to a reinforcing change in another component. In the context of a start-up, increased customer adoption of a product or service can lead to increased revenue and further investment in product development and marketing and hence attracts more customers (Ries, 2011). Conversely, negative feedback loops occur when a change in one component counteracts a change in another component. A negative feedback loop might be the increased operational complexity that comes with rapid growth, which potentially results in decreased efficiency or customer satisfaction if not managed properly (Kazanjian, 1988).

The diagram in Figure 9.2 presents an example of a revision feedback loop of a business start-up.

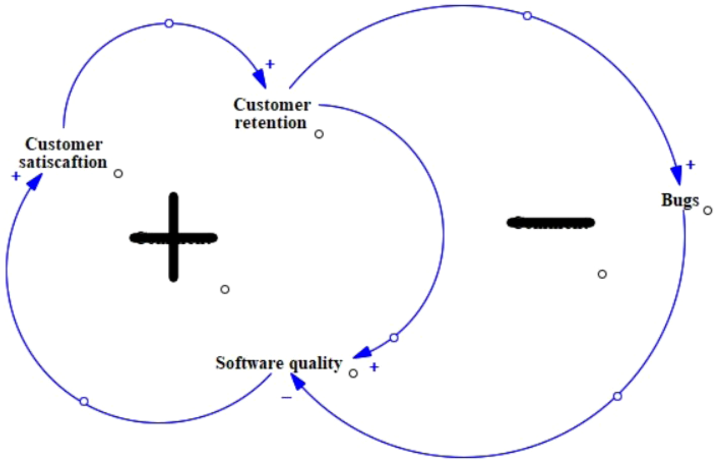


Figure 9.2. Revision feedback loop of a business start-up.

Figure 9.2 outlines and blends the following traits:

Software quality emphasizes the start-up's goal of improving their software by detecting bugs, enhancing features, and ensuring a smooth user experience.
Customer satisfaction presents the satisfaction of customers' experiences as a result of the software quality.
Customer retention outlines the start-up's customer retention based on the customers' satisfaction with the software product.
Software quality deterioration resembles a scenario when a start-up fails to maintain or improve its software quality, which then leads to a decline in customer satisfaction and retention.

In Figure 9.2, the arrows connecting the nodes indicate the corresponding relationships between the components:

The **reinforcing loop** includes software quality, customer satisfaction, and customer retention. These are the driving factors of the start-up's growth and sustainability.
The **balancing loop** includes customer retention and software quality deterioration. These are the menacing factors which may

limit a start-up's growth and success if the software quality is neither maintained nor improved.

9.1.2 *Evolving innovations and emergent learning*

Evolving innovations and emergent learning are essential for the continued growth and success of individuals, organizations, and societies. By examining these phenomena through the lens of systems science, we can better understand the underlying patterns, structures, and dynamics at play.

Emergent properties are novel patterns or behaviors that arise from the interactions between components. In start-ups, the revised and evolved innovations may lead to new market opportunities, competitive advantages, and organizational structures. The introduction of a new product or service can create new customer segments, disrupt existing markets, or require the development of new partnerships and supply chains (Christensen, 2013).

The diagram in Figure 9.3 presents the model of the business start-up revision and evolution cycle.

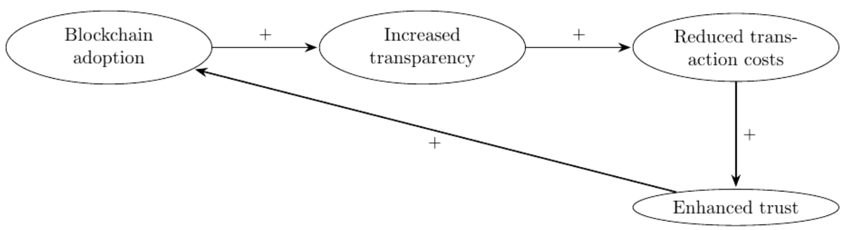


Figure 9.3. Business start-up revision & evolving cycle.

Interconnectedness and complexity, feedback loops and adaptation, self-organization and emergence, resilience and robustness, system dynamics and nonlinearity, and evolutionary processes and co-evolution are essential criteria in systems science for elucidating the complex interconnections and processes involved in evolving innovations and emergent learning.

Interconnectedness and complexity are critical resources for start-ups working on blockchain technology. In particular, it is essential to consider the interconnections and complexity within the financial ecosystem. These assumptions include relationships with banks, regulators, consumers, and other stakeholders. By understanding these interconnections, start-ups can more precisely anticipate and address the challenges and opportunities that arise in a complex environment. A start-up creating a blockchain-based remittance platform must consider the various financial institutions, regulations, and customer needs involved in the process.

Feedback loops and adaptation are vital for start-ups. In fact, it is critical for blockchain finance start-ups to adapt to changing market conditions and user requirements. Feedback loops play a crucial role in this adaptation process, enabling start-ups to learn from their experiences and iterate on their products or services. A start-up offering a decentralized lending platform may collect user feedback on the platform's ease of use, interest rates, and loan approval process. This feedback can inform future iterations of the platform, helping the start-up better serve its users.

Resilience and robustness are essential features for blockchain finance start-ups. In particular, such start-ups must withstand various challenges, such as market fluctuations, regulatory changes, and security threats. By building resilience and robustness into their offerings, start-ups can better prepare for and withstand disruptions. A start-up that designs a blockchain-based trading platform should ensure that the platform can handle high transaction volumes, is resistant to cyberattacks, and can adapt to changing regulations.

System dynamics and nonlinearity are also vital for start-ups. In fact, start-ups must be aware of the nonlinear dynamics in the blockchain finance ecosystem, as small changes can lead to significant impacts. Regulatory changes or the emergence of new technologies may have far-reaching consequences for a start-up focused on blockchain-based financial solutions. By understanding and anticipating these dynamics, start-ups can better position themselves for success in a rapidly evolving market.

Evolutionary processes and co-evolution are critical for blockchain finance start-ups. In order to remain competitive, such start-ups must continually evolve their products, services, and strategies. This often involves co-evolving with their customers, partners, and competitors to create value in the market. A start-up creating a blockchain-based payment system may need to embrace emerging technologies, such as the Internet of Things (IoT) or AI, to enhance its offering and drive further innovation.

The diagram in Figure 9.4 presents the business start-up evolution cycle.

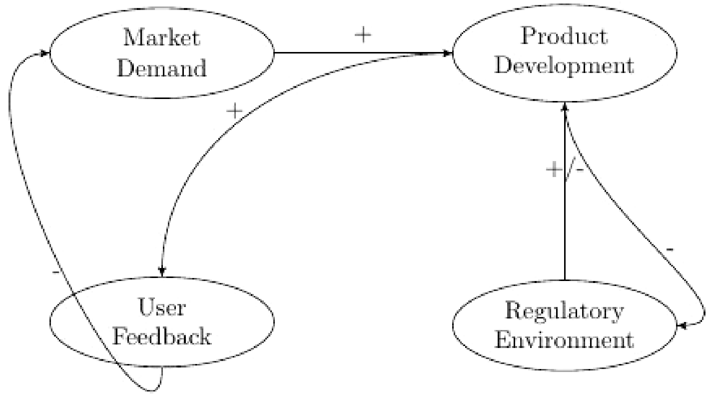


Figure 9.4. Business start-up evolving cycle.

Figure 9.4 reveals the following key relationships in the causal loop diagram:

- Market demand positively influences product development (+). (A)
- Product development positively influences user feedback (+). (B)
- User feedback negatively influences market demand (−). (C)
- The regulatory environment can have both positive and negative influences on product development (+/−). (D)

- Product development negatively influences the regulatory environment (−). (E)

Figure 9.4 also outlines the causal loop diagram with four variables, together with the reinforcing and balancing loops. The **reinforcing loop** emerges due to the positive influence of market demand on product development (A) and the positive influence of product development on customer feedback (B), which in turn negatively influences market demand (C). This loop indicates that an increase in market demand leads to more product development. Hence, this results in more accurate customer feedback that helps enhance the product. The market demand increases as the product improves and therefore leads to a continuous growth and innovation cycle.

The **balancing loop** is formed by the positive or negative influence of the regulatory environment on product development (D) and the negative influence of the product development on the regulatory environment (E). This loop demonstrates that as the regulatory environment changes, it can either positively or negatively affect product development. In turn, product development influences the regulatory environment, resulting in adjustments and adaptations. This balancing loop helps maintain a stable equilibrium in the start-up's growth and innovation.

Market demand plays a significant role, as the demand for blockchain finance solutions in the market influences the start-up's growth and innovation.

Product development is based on market demand and hence becomes an important attribute for start-ups. To stay competitive and current, a start-up must continuously iterate and evolve its product or service.

As a start-up develops and deploys its product or service, customer **feedback** guides the identification and detection of areas that require improvement and hence further innovations.

It is critical for a start-up to adapt to the **regulatory environment**, as changes in regulations affect the start-up's ability to operate and develop its product and service.

9.2 Creativity and Systems Thinking

From a systems science perspective, creativity is a critical component that aids in the accurate understanding and addressing diverse and complex problems. The diagram in Figure 9.5 outlines the fundamentals of creativity and systems thinking in the design of start-ups.

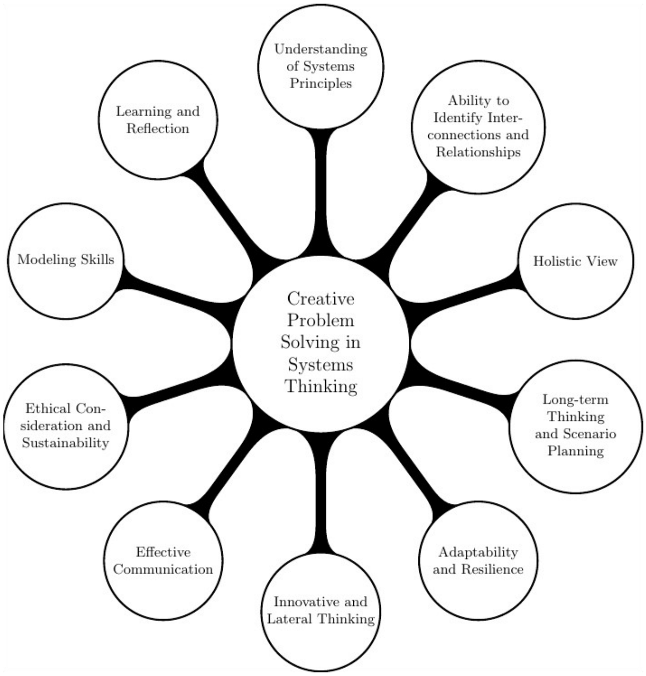


Figure 9.5. Creativity & systems thinking.

Using the iceberg model presented in Figure 3.9, together with Figures 8.2 and 8.3, and using the principles of divergent thinking, emergent learning, rational thinking, making the right choices, and asking the right questions, we can conclude that the role of creativity in systems science is about discovering connections that others might disregard or miss, challenging the standards and the status quo, and envisioning and designing an alternative and brighter future.

9.2.1 *Integrating creativity and systems thinking*

Integrating creativity and systems thinking requires several strategies. First, it is critical to design and stimulate an environment that supports innovative thinking and a two-directional exchange of ideas. This often involves organizational culture changes that encourage all members to exchange ideas and take risks. For instance, for a blockchain start-up, integrating creativity and systems thinking may require regular brainstorming sessions that encourage divergent thinking, welcome numerous ideas, and design cross-disciplinary teams to promote diverse perspectives and solutions.

Integrating creativity and systems thinking can have numerous benefits. Innovative solutions naturally arise, as creativity can lead to the development of unique products and services that emphasize and differentiate a start-up in the marketplace. For a blockchain start-up, this could mean a new platform that revolutionizes financial transactions and supply chain tracking.

Improved decision-making processes are an additional benefit, as the inclusion of diverse perspectives can lead to more balanced, accurate, and informed decisions. A blockchain start-up may be better equipped to navigate regulatory uncertainties by considering various scenarios and responses.

Integrating creativity and systems thinking can foster adaptability. Adaptability is a crucial attribute for start-ups operating in rapidly evolving sectors, such as blockchain. Adaptability allows a start-up to acclimate quickly in response to market changes or new opportunities, ensuring its continued relevance and competitiveness.

On the other hand, numerous challenges arise while blending creativity with systems thinking. The first challenge involves shifting mindsets. Overcoming resistance to change can be particularly difficult in established systems or sectors. For a blockchain start-up, this may involve convincing stakeholders about the advantages, viability, and potential of blockchain technology.

Another challenge comes from finding a precise balance between creativity and systematic constraints. Creativity stimulates new innovative ideas, while systematic approaches often require adherence to certain rules and structures. A blockchain start-up might encounter regulatory constraints or technological limitations that restrict creative solutions.

9.2.2 *Evolving creative problem-solving techniques*

Blending creativity with systems thinking becomes more and more vital due to an increasingly diverse, complex, and uncertain environment. In particular, this is true for blockchain start-ups, as it is essential for them to perpetually innovate to keep up with their competitors. The ability to challenge mental models and foster learning organizations is one of the key ingredients for thriving in this continuously evolving landscape.

Evaluating the effectiveness of blending creativity with systems thinking is essential for emergent learning and future revisions. This requires the development of amiable feedback environments and promoting stimulating individualized and collaborative learning environments. Blockchain start-ups could implement robust feedback mechanisms and hold regular retrospective meetings to assess progress and identify the problematic areas that require revisions. This commitment to ongoing learning and development, both at the individual and organizational levels, can foster continuous improvement and innovation.

The diagram in Figure 9.6 presents the causal loop diagram for evolving creative problem-solving techniques together with systems thinking.

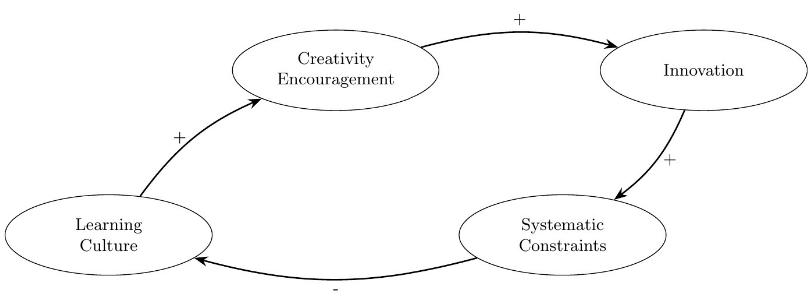


Figure 9.6. Evolving creative problem-solving techniques.

Figure 9.6 unfolds the following characteristics of evolving creative problem-solving techniques together with the principles of systems thinking:

- **Encouraging creativity** stimulates divergent thinking, rational thinking, and asking the right questions and hence leads to new, alternative, and unique ideas. This is represented by a positive causal link (+) leading to "innovation," indicating that as the level of creativity encouragement increases, innovation also increases.
- The application of these novel ideas leads to **innovation** and hence the successful implementation of these creative ideas within the system. The diagram shows that as innovation increases, it positively impacts systematic constraints. This, in fact, implies that more innovation can result in more constraints within the system.
- Examples of **systematic constraints** could include legal, regulatory, and resource-based limitations. On one hand, constraints could be viewed as hindrances. On the other hand, constraints provide structure and order, which are essential for stability. As innovation rises, systematic constraints increase. However, an increase in systematic constraints negatively impacts (−) the learning culture, indicating that too much rigidity may affect and limit the learning curve and creative learning.
- **Learning culture** stimulates continuous learning, exploration, development, and enhancement. A learning culture supports creativity by promoting open-mindedness, curiosity, and the desire to challenge the status quo.
- **Balanced decisions** focus on balancing creativity and innovation, together with factors such as feasibility, cost, risk, and alignment with strategic objectives. This requires a solid base of understanding of the organization's strategic priorities and the ability to make the right choices.

9.2.3 *Expanding creative problem-solving techniques*

The diagram in Figure 9.7 presents an octagonal loop diagram that outlines the expanding creative problem-solving techniques together with systems thinking.

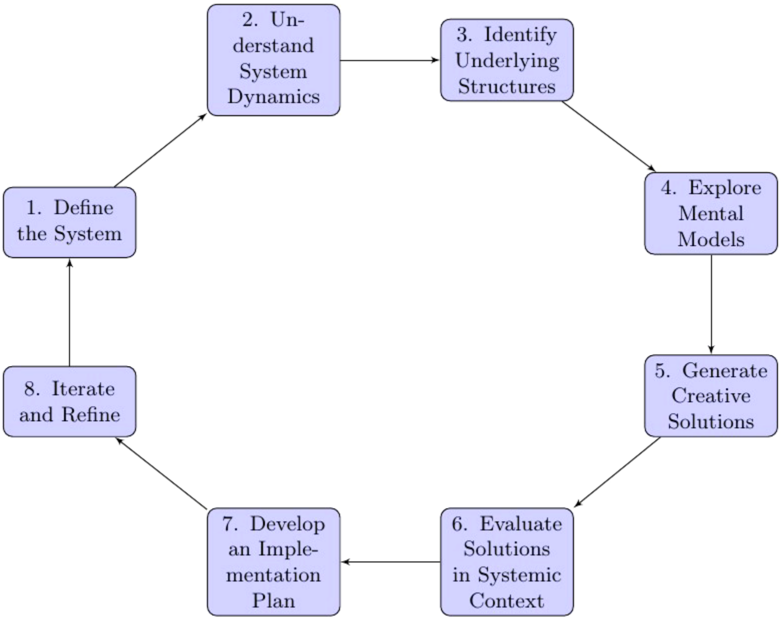


Figure 9.7. Expanding creative problem-solving techniques.

Figure 9.7 reveals the following features of expanding creative problem-solving techniques together with the principles of systems thinking:

- **Defining the system** is the first critical step of the cycle. By defining the system, you identify all the relevant elements and their relationships. Second, you frame and accurately trace the problem within the larger system.

  A blockchain finance start-up operates within the larger financial transaction ecosystem. Therefore, it is vital to identify all the key players and the interactions among them.
- **Understanding the system dynamics** is the next crucial step of the cycle. In particular, it identifies the recurring patterns, feedback loops, and dynamics that may affect the situation.

  One feedback loop could be hesitant to grant leadership to some users, which then reinforces additional hesitancy.

- **Identifying the underlying structures** indicates the underlying structures that influence and dictate the dynamics.

  The traditional banking system structure may be the dominant barrier to adopting blockchain platforms.
- By **exploring the mental models**, you consider assumptions, beliefs, and value orientations (mental models) that could be potential contributing factors to the problem.

  A possible mental model could be the belief that a blockchain is too complex or risky, which could negatively influence the user adoption.
- Divergent thinking and brainstorming a wide range of solutions, such as conventional and unconventional ideas, which **generate creative solutions** and encourage thinking beyond your comfort zone and the immediate system.

  Potential solutions include education initiatives about blockchain, partnerships with traditional banks, and revising the user interface to make it more accessible and user-friendly.
- **Evaluating solutions in a systemic context** sketches a scheme of the potential impacts of each solution in the system. Consider how each solution fits with the system's dynamics and your organization's goals.

  Investing in educational initiatives and partnerships may disrupt the hesitancy feedback loop and thus encourage more people to adopt the platform.
- The final step of the cycle is to **develop an implementation plan** by designing a step-by-step action plan for the chosen solution and by examining the system's dynamics.

9.3 Innovations, Inertial Thinking and Methods

Cognitive inertia is interpreted as an individual's tendency to resist change. In 1960, William J. McGuire applied cognitive inertia to accurately study the initial resistance to change. In particular, he examined people's reactions after a new innovative idea was developed and how their reactions conflicted with the new innovative idea (McGuire, 1960). The diagram in Figure 9.8 sketches a mind map diagram that outlines the balance between cognitive inertia and new innovative ideas in blockchain finance.

Figure 9.8. The mind map of blockchain finance.

Figure 9.8 presents the categorization of key challenges in applying blockchain technology in finance. The mind map evolves as you delve deeper into each issue, design and generate solutions, and get more insights into the problem of applying blockchain technology in finance.

Observe that the mind map starts with a central node labeled "Problems of Blockchain in Finance." From this central point, five main branches radiate outward, each representing a key category of problems: "Security," "Regulation," "Adoption," "Scalability," and "Integration with existing systems."

Note that each branch of the mind map represents a special area to be examined thoroughly. By applying Figure 9.8, you either handle each task one at a time or tackle multiple tasks simultaneously. It is essential to review and revise the mind map to detect new issues that may arise and progress further.

The mind map is also a beneficial tool for visualizing these complex issues, facilitating more accurate understanding and aiding in the development of strategies for solving problems. In particular, the process of designing a mind map is a supplemental opportunity for enhancing divergent thinking, rational thinking, asking the right questions, and making the right choices. It is pertinent to revise the mind map iteratively as the problem-solving process progresses.

9.3.1 *Staying abreast: Traditional vs. new methods*

Staying abreast is critical for entrepreneurs to keep up with and be ahead of their competitors. It is also essential for educators to keep up with educational reforms, new and enhanced technologies, students' preparation levels, students' learning styles, and economic and international influences. Figure 9.9 portrays the essential attributes that guide you to staying abreast and current.

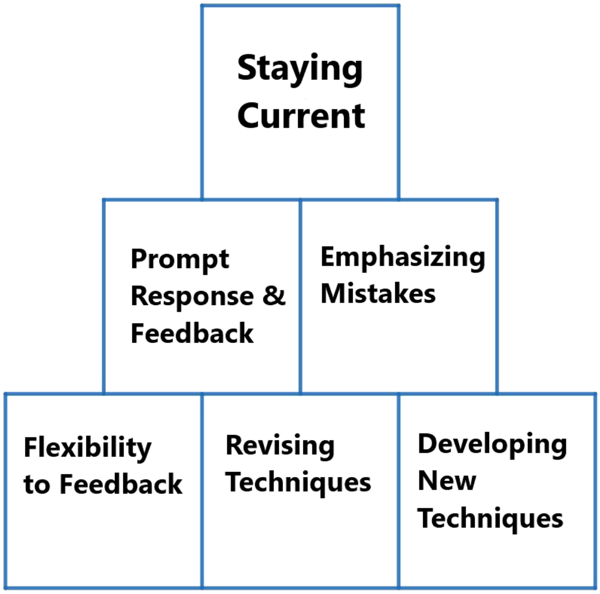


Figure 9.9. The essential attributes of staying abreast and current.

Prompt response and feedback are important two-directional communication features between the entrepreneur and the clients, or between the professor and the students, and they preserve a fresh scheme. This tactic provides a tentative schedule and recommended guidelines throughout the outlined plan.

Immediate emphasis on mistakes is the next crucial two-directional trait that maintains a fresh perspective, communication, and trust and keeps the entrepreneur and the clients or the professor and the students abreast of the progress.

Flexibility to feedback is also a vital two-directional attribute that sustains a fresh perspective between the entrepreneur and the clients, or between the professor and the students.

For instance, in the online teaching and learning environment, this includes amiable graded feedback to students instead of punitive feedback and recommending an alternative solution to a specific problem. In addition, this encompasses keeping students on track with the submission of homework assignments and staying abreast of the material. From our experiences in teaching online courses, students really appreciate friendly reminders to submit an assignment and why it is important to work on assigned homework assignments.

Revising and developing new techniques is another two-directional trait that nurtures a fresh attitude in the learning and design of a start-up environment. Examples of revisions include detecting mistakes and missing fragments, correcting mistakes, and including more details. Revisions enhance effective two-directional communication between the entrepreneur and the clients, or between the professor and the students, and guide clients and students to cognitive skills and the rudiments of self-assessment.

Are new methods necessarily better than the traditional methods? When do you apply the traditional methods? When do you switch to using the new methods? When do you apply specific combinations of the methods? The diagram in Figure 9.10 presents a Venn diagram of the scheme of using traditional versus current methods and addresses these questions.

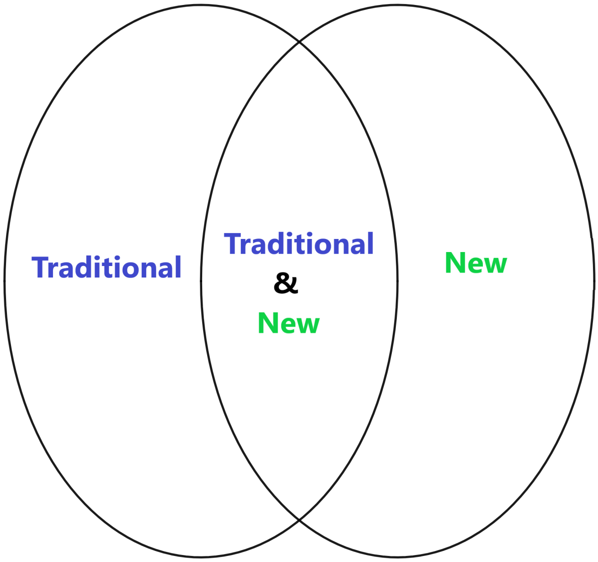


Figure 9.10. Venn diagram: Traditional vs. current methods.

By applying Figure 9.10, Section 9.3.2 will thoroughly examine the similarities and contrasts between the traditional and new techniques, and when and how to utilize them.

9.3.2 *Traditional vs. new techniques*

The **traditional systems thinking methodologies** primarily focus on designing causal loop diagrams, system dynamics models, and the study of cybernetics.

Causal loop diagrams are graphical tools used to visualize how interrelated variables affect one another within a system. Each diagram consists of variables linked by arrows denoting causality, with signs (+/−) at the arrowheads indicating whether the variables change in the same or opposite directions. The signs (+/−) also indicate the direct or indirect relationship between the variables. The loops in each diagram are either labeled "B" (balancing) or "R" (reinforcing), depending on whether they seek equilibrium or exponential growth/decline.

System dynamics models are mathematical simulations used to accurately trace the dynamic behavior of complex systems over time. These models were developed by Jay Forrester and his team at MIT during the 1950s and 1960s. System dynamics models use stocks (quantities), flows (rates), and feedback loops to describe and analyze systems. They are particularly useful for studying systems where changes occur over time and where the past influences the future.

Cybernetics focuses on the study of regulatory and self-regulating systems. It considers the feedback and control mechanisms that allow systems to maintain the desired states and achieve specific goals. The principles of cybernetics apply to any system that has a goal. These include mechanical systems, biological organisms, ecosystems, societies, and individual psychology.

Newer methodologies in systems thinking, such as complexity theory and agent-based modeling, focus more on adaptation, emergence, and self-organization.

Complexity theory, also known as complexity science, examines how relationships between components of a system give rise to the collective behaviors of the system. In addition, complexity theory analyzes how the system interacts with the surrounding environment and forms relationships with its environment. Complexity theory helps us understand various systems with many diverse interacting parts, which may lead to unexpected emergent properties. This approach is applied across many disciplines where systems exhibit complex behavior. These include physics, biology, and economics.

Agent-based modeling is a computational method that allows a researcher to create, analyze, and experiment with agent-based models that interact within a system. Each agent represents a component within the system with individual behavior rules, and the interactions among these agents lead to emergent system-level behavior. Agent-based models are applied in various fields, such as ecology, economics, sociology, and computer science. Agent-based models aid in analyzing complex phenomena, such as flocking behavior, market dynamics, and social behaviors.

9.4 Synergy Effect

The **synergy effect** is defined as teamwork and collaboration efforts that produce a complete result that is greater than the sum of individual efforts. During class discussion or in a research project, collaborative learning can be more effective that the sum of individualized learnings. This occurs due to a two-directional exchange of ideas, as each individual sees specific details that others may not see. Section 9.4.1 will explore the essentials of the synergy effect.

9.4.1 *Essentials of the synergy effect*

Figure 9.11 outlines the essentials of the synergy effect.

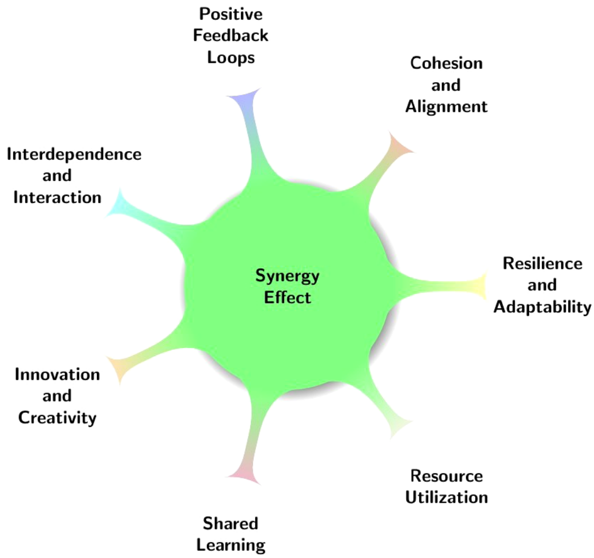


Figure 9.11. The essentials of the synergy effect.

Figure 9.11 describes the following characteristics of the synergy effect:

Quantifiable outcomes focus on detecting the traits of the synergy effect through quantifiable improvement in a certain outcome or performance indicator. This could imply increased productivity, improved efficiency, higher quality, or any other measurable result.

Complex problem-solving techniques emphasize the essence of the synergy effect that aim to tackle complex problems. In particular, synergistic systems resemble strong and reliable problem-solving capacities as they can leverage the combined skills, knowledge, and capabilities of the system's parts.

Innovations and creativity often spark new ideas and innovative solutions. The synergy effect can ignite a stimulus to be innovative and creative within a system.

The synergy effect often reveals **collaborative learning and shared learning**. Synergistic systems often exhibit a high degree of shared learning. In particular, information and insights flow freely and are widely distributed throughout the system, which enhance learning and improvement.

Resource utilization is an important characteristic of the synergy effect as it focuses on maximizing outcomes within limited resources. Resource utilization implies efficiency, cost savings, reduced waste, and improved sustainability.

Synergetic systems are **resilient and adaptable** to changes as they are flexible and diverse and encourage collaborative and shared learning. In addition, various parts work together to manage and absorb shocks and changes and hence adapt as necessary.

Synergic systems present stability as well as strong **cohesion and alignment**. In particular, the system's parts work together toward achieving a common goal while their efforts are coordinated and synchronized.

The components of synergic systems exhibit strong **interdependence and interaction**. This phenomenon occurs as the overall synergy effect strongly depends on the interdependence and interaction among the system's parts.

Synergistic systems often unfold **positive feedback loops**. The success of one part contributes to the success of others, and vice versa.

Section 9.4.2 links the synergy effect with the six modes of behavior examined in Chapter 4.

9.4.2 *Synergy effect, patterns and interactions*

Figure 4.5 and Sections 4.1–4.6 outline the following six modes of behavior, their characteristics, and their similarities and contrasts: exponential growth, goal-seeking growth, S-shaped growth with overshoot, S-shaped growth, oscillation and overshoot, and collapse. The diagram in Figure 9.12 illustrates how different growth patterns can emerge and interact within a system.

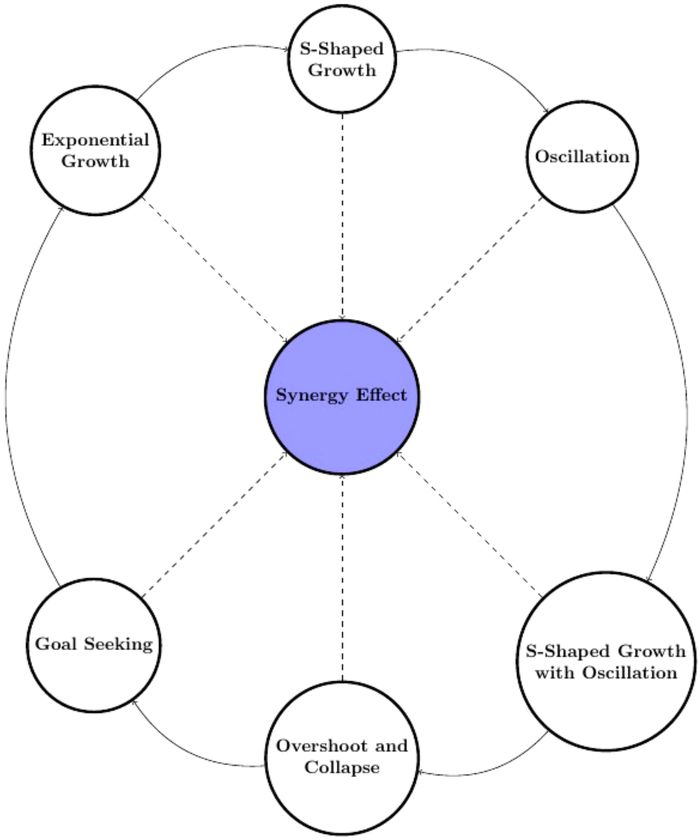


Figure 9.12. Synergy effect, patterns & interactions.

Figure 9.12 presents the following examples of links among the six modes of behavior.

The **exponential growth pattern** can transition to an **S-shaped growth pattern** when limiting factors emerge and the growth rate slows down.
The **S-shaped growth pattern** can transition to an **oscillation pattern** when periodic fluctuations arise in a system's performance or when external factors cause oscillatory behavior.

The **oscillation pattern** can transition to an **S-shaped growth with oscillation pattern** when a system encounters a periodic underlying growth trend.

The **S-shaped growth with oscillation pattern** can transition to an **overshoot and collapse pattern** when a system exceeds its sustainable limits and experiences a subsequent decline or collapse.

The **overshoot and collapse pattern** can transition to a **goal-seeking pattern** when a system redirects its focus toward a specific goal, orientation, or desired state, while seeking to stabilize and improve its performance.

9.5 Questions, Iterative Cycles and Patterns

Figure 8.12 in Section 8.2.3 outlines and describes the contrasting traits between easy and right choices. On one hand, **easy choices** can be interpreted as recommended choices based on colleagues' experiences and intuitions. Easy choices can be quick choices that require a very meager comparison of similarities and contrasts and a short process. Easy choices relate to factors that resemble the visible components of the iceberg model.

On the other hand, **right choices** can be interpreted as choices that lead to the desired outcomes, positive consequences, and long-term effects. Right choices are often made based on conclusions drawn from numerous observations that thoroughly analyze data and facts. Comparing similarities and contrasts between concepts, themes, data, facts, disciplines, and cultures can be frequently encountered while attempting to make the right choices.

The diagram in Figure 9.13 presents the three-question iterative cycle.

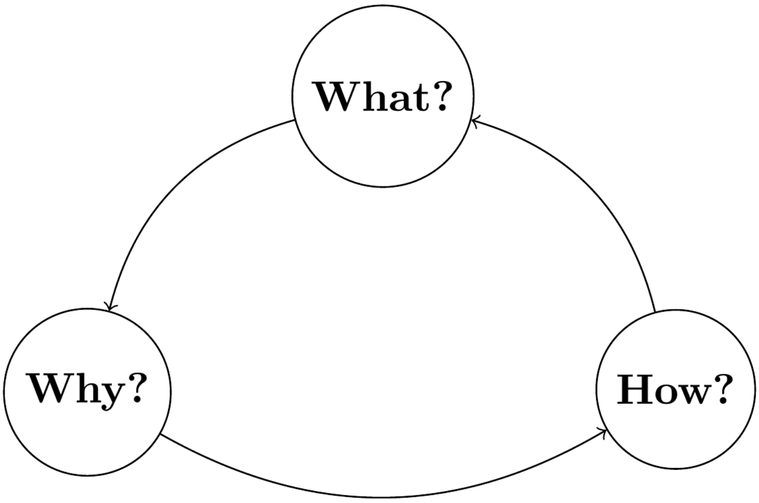


Figure 9.13. The three-question iterative cycle.

Asking the three essential questions: "Why?" "What?" and "How?" aids us in accurately understanding and tracing the six modes of behavior. Asking these questions often guides us in analyzing the iterative cycles of inquiry. Our understanding of the characteristics of each mode of behavior deepens during each iteration of the cycle presented in Figure 9.13. Hence, this stimulates you to revise and enhance your previous knowledge. This iterative approach is essential for studying complex systems, where behavior often arises from the interaction of multiple factors. The following six sections link Figure 9.13 with the six modes of behavior discussed in Sections 4.1–4.6 in Chapter 4.

9.5.1 *Exponential growth pattern*

In Section 4.1, the characteristics of the **exponential growth pattern** are presented in Figure 4.6. Exponential growth occurs when a quantity's rate of change is proportional to that quantity's current value. As the quantity increases, the growth rate also increases, leading to rapidly accelerating growth. Conversely, as the quantity decreases, the rate of decay accelerates as well.

The diagram in Figure 9.14 addresses the what, why, and how questions and outlines the three iterations of the exponential growth pattern's three-question iterative cycle.

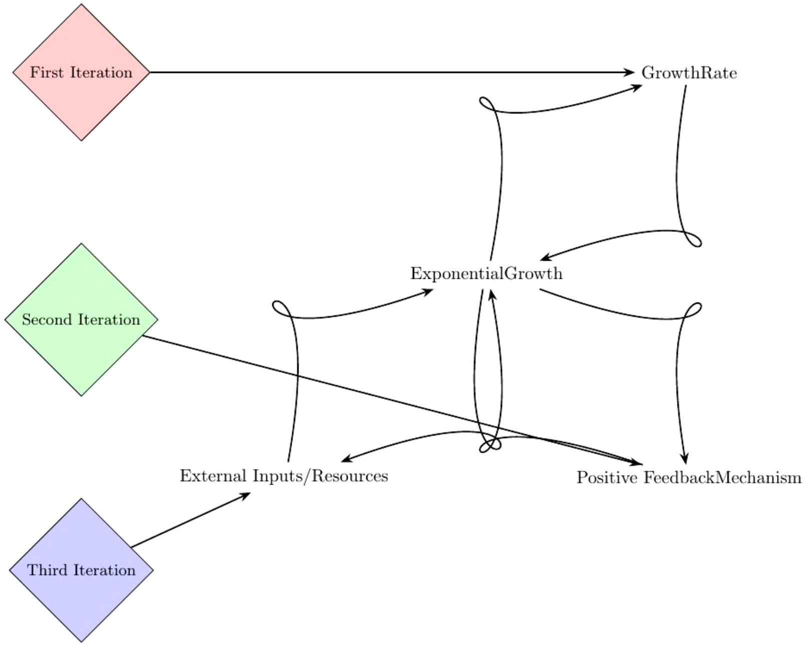


Figure 9.14. The three iterations of the exponential growth pattern.

The first iteration emphasizes the corresponding virtues of the three questions presented in Figure 9.14:

- First, **what** is the specific mechanism of the exponential growth? The mechanism is the constant rate of growth relative to the current size or value, leading to increasingly rapid growth over time.
- Next, we ask **why** the exponential growth emerges. The exponential growth emerges as the growth rate of the value of a mathematical function is proportional to the function's current value. In real-world terms, this often happens when there are no limits on growth.

- Finally, we ask **how** does exponential growth arises. The exponential growth arises through a positive feedback loop, where the initial growth leads to additional growth, which in turn leads to even more growth, and so on.

After thorough observations and consequent revisions from the first iteration, the second iteration indicates the following traits of the three questions presented in Figure 9.14:

- First, **what** is the revised specific mechanism of the exponential growth? The specific mechanism involves not only the internal dynamics of growth but also the potential external influences that can amplify the rate of growth. These include additional resources, technological advancements, and additional beneficial environmental conditions.
- Next, we ask **why** the exponential growth reoccurs. The exponential growth reoccurs not only due to an inherent positive feedback mechanism but can also be influenced by external inputs or resources that may fuel further growth.
- Finally, we ask **how** the exponential growth comes about again. The exponential growth arises through the interconnections of the internal positive feedback and, potentially, external inputs or resources. These lead to a rapidly increasing growth rate.

After rigorous observations and revisions from the first and second iteration, the third iteration underlines the cognate features of the three questions presented in Figure 9.14:

- First, **what** is the specific mechanism of the exponential growth? The specific mechanism of exponential growth involves the positive feedback loop inherent in the system, potential amplification from external factors, and the relative absence of limiting factors that would otherwise curtail growth.
- Next, we ask, **why** the exponential growth arises. The exponential growth arises due to the combination of internal positive feedback mechanisms, external inputs or resources, and the absence of significant growth limitations or constraints.

• Finally, we ask, **how** the exponential growth occurs. The exponential growth occurs through the compound effect of growth upon growth. The growth is amplified by external inputs or advantageous conditions, which are unhindered by significant limitations or constraints.

9.5.2 *Goal-seeking pattern*

In Section 4.2, the characteristics of the **goal-seeking pattern** are presented in Figure 4.9. The goal-seeking pattern aims to find an optimal solution to a problem by adjusting the values of certain variables by outlining the objectives and then using trial-and-error methods or algorithms to determine the solutions that satisfy the goals. Goal seeking is a beneficial tool for accurate modeling of complex system dynamics over time by studying and understanding the primary roots of the problem rather than simply looking at the symptoms.

The diagram in Figure 9.15 addresses the what, why, and how questions and outlines the three iterations of the goal-seeking pattern's three-question iterative cycle.

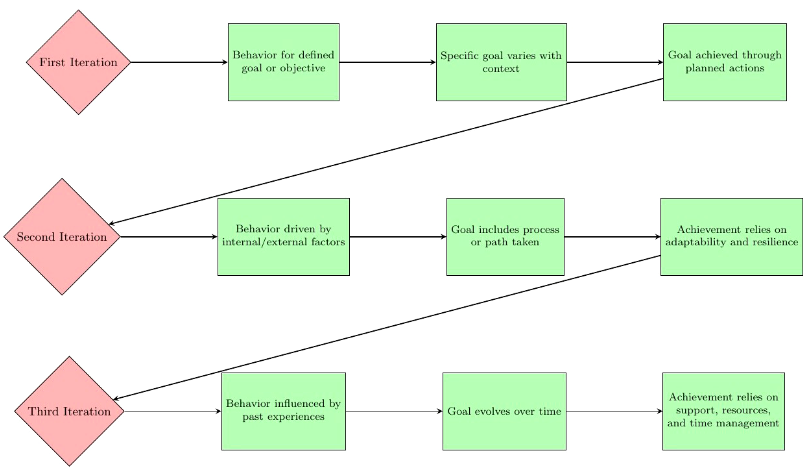


Figure 9.15. The three iterations of the goal-seeking pattern.

The first iteration emphasizes the corresponding features of the three questions presented in Figure 9.15:

- First, **what** is the specific goal or objective? The specific goal could vary widely depending on the context. Such examples include, finishing a project by a specific deadline, writing a book, or scoring a goal in a soccer game.
- Next, we ask **why** this behavior occurs. The behavior occurs when there is a defined goal or objective that needs to be accomplished.
- Finally, we ask **how** a specific goal will be achieved. The goal is achieved through a series of planned and organized actions. These often involve problem-solving, decision-making, and strategic planning techniques.

After thorough observations and consequent revisions from the first iteration, the second iteration indicates the following traits of the three questions presented in Figure 9.15:

- First, **what** is the specific goal or objective? The specific goal is not only the final destination but also includes the specific path to reach the destination, which can impact the satisfaction or rewards gained.
- Next, we ask **why** the behavior reoccurs. Beyond the presence of a defined goal, there may be additional factors driving this behavior. These could be potential internal motivations, such as intrinsic satisfaction or reward expectation, or external factors, such as social approval or avoidance of negative outcomes.
- Finally, we ask **how** this new goal is achieved. Achieving the new goal does not only rely on planned actions but also includes factors such as adaptation capacity and reactions to unexpected circumstances and obstacles. Examples include learning from failures, resilience, and creative and new problem-solving techniques.

After rigorous observations and revisions from the first and second iteration, the third iteration underlines the cognate features of the three questions presented in Figure 9.15:

- First, **what** is the new specific goal or objective? The new specific goal is a dynamic concept and may evolve over time based on feedback, learning, and changing circumstances.
- Next, we ask, **why** the behavior reoccurs. The behavior reoccurs not only because of the defined goal and internal/external factors,

but may also be influenced by past experiences, learned behaviors, and conditional responses.

- Finally, we ask **how** to achieve this new goal. The new achievements rely on combinations of deliberate actions, adaptability, and resilience. In addition, new achievements rely on time management, potential resources, and support and collaboration from colleagues.

9.5.3 *S-shaped growth with overshoot pattern*

In Section 4.3, the characteristics of the **S-shaped growth with overshoot** pattern are presented in Figure 4.12. In dynamic systems, S-shaped growth with overshoot is a specific behavior where an initial input transitions from a gradual increase to a rapid acceleration as it approaches its maximum. This often emerges as an S-shaped curve when graphed out on paper. However, if not monitored, this can arise as an exponential growth. This implies that minor changes may have large effects after some period of time.

The diagram in Figure 9.16 addresses the what, why, and how questions and outlines the three iterations of the S-shaped growth with overshoot pattern's three-question iterative cycle.

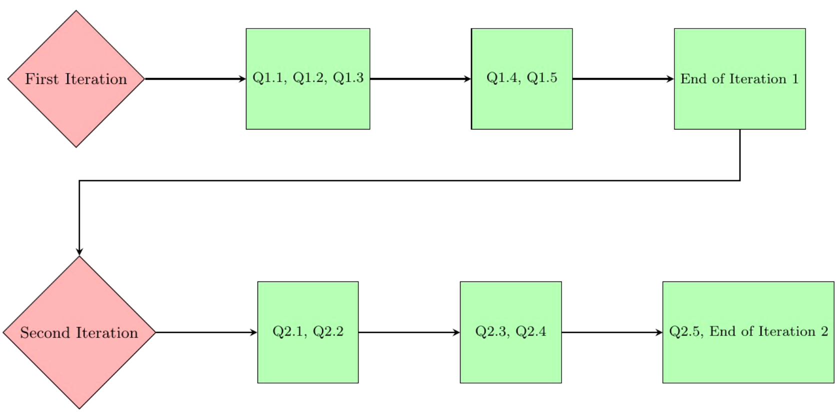


Figure 9.16. The three iterations of the S-shaped growth with overshoot.

The first iteration emphasizes the corresponding characteristics of the three questions presented in Figure 9.16:

Q1.1 Why does the system exhibit an initial rapid growth?
Q1.2 What factors contribute to this initial phase of growth?
Q1.3 How does the system's carrying capacity influence its growth trajectory?
Q1.4 Why does the gradual growth decay emerge as an S-shaped curve?
Q1.5 What is the significant role of the feedback mechanisms in the gradual growth decay?

After thorough observations and consequent revisions from the first iteration, the second iteration indicates the following virtues of the three questions presented in Figure 9.16:

Q2.1 Why does the system occasionally overshoot its carrying capacity, which then leads to oscillatory behavior?
Q2.2 What mechanisms within the system may stimulate these overshoots, oscillations, and subsequent revisions?
Q2.3 How do supplemental factors, such as time delays, nonlinear responses, and random fluctuations, contribute to these overshoots and oscillations?
Q2.4 What additional changes should we consider in our model to capture and describe these dynamics more accurately?
Q2.5 How could we improve the accuracy of our model in describing the S-shaped growth and the associated oscillations?

9.5.4 *S-shaped growth pattern*

In Section 4.4, the characteristics of the **S-shaped growth pattern** are presented in Figure 4.15. The S-shaped growth pattern is a beneficial tool in systems thinking as it can aid individuals and organizations in understanding and tracing complex systems' behavior over time. This pattern analyzes and emphasizes the sources of growth and the limiting factors and presents opportunities for individuals and organizations to make more accurate and precise decisions and future planning.

The diagram in Figure 9.17 addresses the what, why, and how questions and outlines the three iterations of the S-shaped growth pattern's three-question iterative cycle.

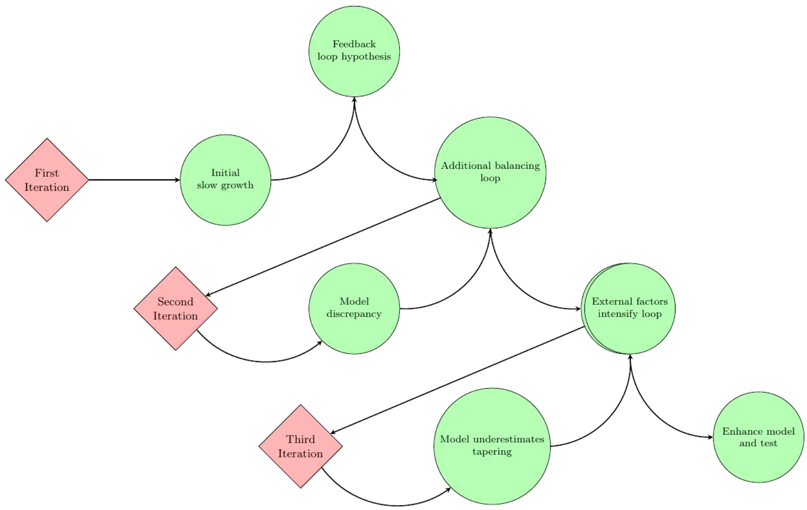


Figure 9.17. The three iterations of the S-shaped growth pattern.

The first iteration emphasizes the corresponding characteristics of the three questions presented in Figure 9.17:

- First, **what** we observe is an initial slow growth that accelerates and then gradually tapers off.
- Next, we ask **why** our initial hypothesis could lead to a reinforcing feedback loop during the acceleration and a balancing feedback loop during the tapering phase.
- Finally, we ask **how** to confirm the hypothesis. To justify the hypothesis, we design a base model by applying these feedback loops and testing them with very thorough and accurate observations.

After thorough observations from the first iteration, the second iteration indicates the following traits of the three questions presented in Figure 9.17:

- First, while observing, we ask **what** occurs and reoccurs. The model's behavior matches our observations but may not fully capture the initial slow growth phase.
- Next, we ask **why** such a discrepancy may occur during different iterations. Perhaps there may exist another balancing loop that impedes the initial growth.
- Finally, we ask **how** to precisely describe this phenomenon by comparing similarities and contrasts. In fact, we revise our model by including a new feedback loop and test it again with very thorough and accurate observations.

After rigorous observations and revisions from the first and second iterations, the third iteration underlines the cognate features of the three questions presented in Figure 9.17:

- First, we ask **what** missing fragments arise. After revising, our model captures the initial slow growth more accurately but still underestimates the tapering phase of the curve.
- Next, we ask **why** missing fragments occur. At this phase, our hypothesis suggests that there may be additional external factors or constraints that were not previously considered in our model. In particular, this could be a limiting resource, market saturation, or increased competition, which intensifies the balancing feedback loop in the tapering phase.
- Finally, we ask **how** to capture and describe these dynamics more precisely. To accurately trace these dynamics, we enhance our model by considering additional factors and conducting more testing. We proceed with this iterative process until our model adequately captures the observed behavior. This iterative process unfolds numerous details about the dynamics of the S-shaped growth pattern.

9.5.5 *Oscillation pattern*

In Section 4.5, the characteristics of the **oscillation pattern** are presented in Figure 4.18. The oscillation pattern in dynamic systems examines the fluctuation of values or variables between two extremes over time within the system. This can arise as an alternating pattern, where each extreme occurs at the crest of the oscillation and then reverses the direction toward the opposite point on the spectrum (which is the trough of the oscillation). Oscillations often arise as a consequence of feedback loops. In fact, this occurs when changes to one variable cause other related variables to change, which then causes further adjustments that eventually lead back to the main cycle (Sterman, 2000).

The diagram in Figure 9.18 addresses the what, why, and how questions and outlines the three iterations of the oscillation pattern's three-question iterative cycle.

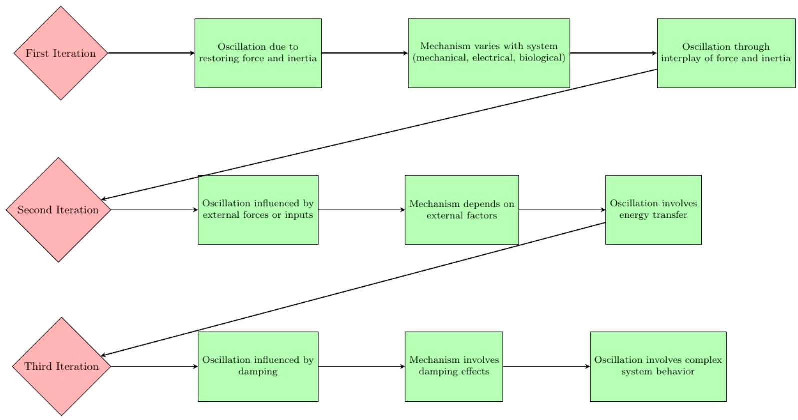


Figure 9.18. The three iterations of the oscillation pattern.

The first iteration emphasizes the corresponding characteristics of the three questions presented in Figure 9.18:

- First, **what** is the specific mechanism of the oscillation? The specific mechanism of the oscillation could be mechanical (as in a pendulum swinging), electrical (as in a circuit with resistors and capacitors), or even biological (such as the circadian rhythms).
- Next, we ask **why** the oscillatory behavior occurs. The oscillatory behavior arises due to a balancing force that restores the system to its equilibrium state. This is then counteracted by inertia, which transfers the system past its equilibrium.

- Finally, we ask **how** the oscillation arises. The oscillatory pattern emerges through the constant interaction of force and inertia, or similar opposing factors in non-physical systems. These result in a repetitive cyclical or a back-and-forth motion.

After thorough observations from the first iteration, the second iteration indicates the following traits of the three questions presented in Figure 9.18:

- First, **what** is the specific mechanism of the oscillation? The specific mechanism of the oscillation not only depends on the nature of the system, but also depends on how the system is driven or influenced by external factors. Changing the input voltage can affect an oscillating electrical circuit.
- Next, we ask **why** the oscillatory behavior reoccurs. The oscillatory pattern behavior arises due to balancing forces and inertia and due to external forces or inputs. These include the system's supplied energy.
- Finally, we ask **how** the oscillatory pattern comes about again. In addition to balancing forces, inertia, and other opposing factors, the oscillatory behavior also involves energy transfer within the system. Energy transfer may be influenced by damping or other forms of energy loss.

After rigorous observations and revisions from the first and second iterations, the third iteration underlines the cognate features of the three questions presented in Figure 9.18:

- First, **what** is the specific mechanism of the oscillation? The specific mechanism of an oscillatory pattern can be very complex. In fact, this may involve not only the inherent characteristics of the system and external forces, but also the effects of damping, which can introduce nonlinearity into the system's behavior.
- Next, we ask **why** the oscillatory behavior is reoccurring? The oscillatory behavior reoccurs due to a combination of balancing forces, inertia, and external inputs. The oscillatory behavior can also be heavily influenced by the damping factors present in the

system, which can lead to changes in the amplitude or frequency of the oscillations.

- Finally, we ask **how** the oscillation comes about again. The oscillation pattern reoccurs as a combination of internal dynamics (force and inertia), external inputs, energy transfer, and damping effects. These lead to complex system behavior that can often be accurately described using differential equations or other advanced mathematical tools and models.

9.5.6 *Overshoot and collapse pattern*

In Section 4.6, the characteristics of the **overshoot and collapse pattern** are presented in Figure 4.21. The overshoot and collapse pattern in dynamic systems arises when a rapidly ascending initial value achieves its maximum and then quickly descends back to the original starting point. In this situation, the overshoot indicates how far the dynamics occur past its peak prior to collapsing again.

The corresponding diagram in Figure 9.19 addresses the what, why, and how questions and outlines the three iterations of the overshoot and collapse pattern's three-question iterative cycle.

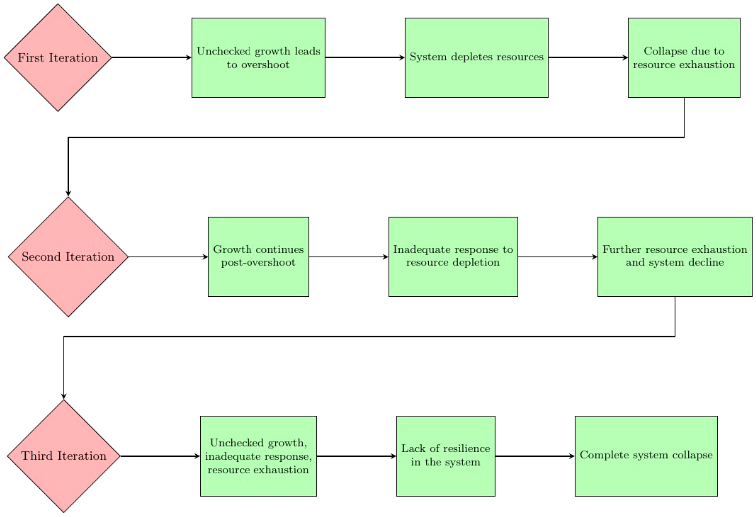


Figure 9.19. The three iterations of the overshoot & collapse pattern.

The first iteration emphasizes the corresponding characteristics of the three questions presented in Figure 9.19:

- First, **what** is the specific mechanism of the overshoot and collapse? The mechanism often involves rapid growth and depletion of resources. As a result, this leads to the inability of the system to sustain its size or rate of consumption and hence to a rapid decrease or collapse.
- Next, we ask **why** the overshoot and collapse pattern is occurring. The overshoot and collapse pattern occurs when a system's growth exceeds its carrying capacity or its sustainable limit. As a result, it depletes the resources it depends upon and hence leads to a rapid decline or collapse.
- Finally, we ask **how** the overshoot and collapse arises. The overshoot and collapse pattern arises from the uncontrolled or unchecked growth of a system beyond its sustainable limits. This significantly contributes to resource exhaustion and subsequent decline.

After thorough observations from the first iteration, the second iteration indicates the following traits of the three questions presented in Figure 9.19:

- First, **what** is the modified version of the specific mechanism of the overshoot and collapse pattern? The revised mechanism involves not only unchecked growth and resource depletion, but also a lack of adequate feedback mechanisms to curb growth or conserve resources before it's too late.
- Next, we ask **why** the overshoot and collapse pattern is reoccurring. First, this pattern reoccurs due to rapid and accelerated growth and resource depletion. Second, the overshoot and collapse may also be influenced by the system's inability to adapt to rapidly decreasing resources or to recover from the overshoot.
- Finally, we ask **how** the overshoot and collapse pattern reoccurs. First, this pattern reoccurs as uncontrolled growth as an inadequate response to resource depletion. Hence, this results in the

eventual exhaustion of critical resources and gradually leads to the system's decline.

9.6 End of Chapter Summary

Systems thinking is an essential concept that stimulates divergent thinking, rational thinking, and emergent learning and unfolds new opportunities for designing creative and innovative ideas. The fundamentals of systems thinking promote individualized learning, collaborative learning, a balance between leading and following, and two-directional communication. Systems thinking also guides one to the principles of the synergy effect and to an amiable and yet diverse and complex working atmosphere with a two-directional exchange of ideas. The rudiments of systems thinking develop and enhance our critical thinking and cognitive and comparison skills and energize a cross-disciplinary and cross-cultural innovative environment.

The principles of systems thinking also foster comparison skills, which highlight the following dilemmas: convergent vs. divergent thinking, continuous vs. emergent learning, soft vs. hard tools, internal vs. external feedback, emotional vs. rational thinking, good vs. right questions, easy choices vs. right choices, and traditional vs. new ideas. The principles of systems thinking then stimulate the following questions: What are the advantages and disadvantages of these dilemmas? Which dilemma is a better choice to achieve a specific task? How do you keep the balance between the two dilemmas?

9.7 Further Thoughts

1. In Section 9.2, we discussed creativity and systems thinking. How do you decompose creativity and systems thinking by applying internal and external influences and feedback? How do you decompose creativity and systems thinking with applying simplicity and complexity? How do you decompose creativity and systems thinking by applying traditional and new ideas?

2. In Section 9.4, we discussed the essence of the synergy effect. Does the synergy effect always work more effectively than individualized learning and efforts?
3. In Section 9.5, we discussed the essence of questions and iterative cycles and patterns. What percent of revisions occur in each question from one iteration to the next in each pattern? What is the minimum percent of revisions required to notice positive effects?

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Appendix

Categories of Leadership

1. Primal leadership.
2. Resonance leadership.
3. Self-leadership.
4. Sustainable leadership.
5. Transformational leadership.

Categories of Learning

1. Collaborative learning.
2. Continuous learning.
3. Cross-cultural learning.
4. Cross-disciplinary learning.
5. Cross-organizational learning.
6. Emergent learning.
7. Group learning.
8. Individualized learning.
9. Organization learning.
10. Shared learning.

Categories of Thinking

1. Abstract thinking.
2. Convergent thinking.
3. Divergent thinking.
4. Emotional thinking.
5. Rational thinking.

Leadership Roles

1. Pedagogical role.
2. Social role.
3. Managerial role.
4. Facilitation role.

Patterns: Six Modes of Behavior

1. Exponential growth pattern.
2. Goal-seeking pattern.
3. S-shaped growth with overshoot pattern.
4. S-Shaped growth pattern.
5. Oscillation pattern.
6. Overshoot & collapse pattern.

Fundamentals of Systems Thinking

1. Diversity.
2. Complexity.
3. Relationships (or interconnections) between components.
4. Analysis.
5. Synthesis.
6. Patterns.
7. Emergent learning:
   - 7.1 Unforeseen and unexpected consequences.
   - 7.2 Adapting to new circumstances (changes).

Key Contributors to Systems Thinking

1. Russell Ackoff.
2. W. Ross Ashby.
3. Peter Checkland.
4. Jay W. Forrester.
5. Eliyahu M. Goldratt.
6. Donella Meadows.
7. Peter Senge.
8. John Sterman.

Key Contributors to Management

1. Henri Fayol.
2. Mary Parker Follett.
3. George Elton Mayo.
4. Frederick Taylor.
5. Max Weber.

Key Contributors to Leadership

1. Bernard Bass.
2. Ken Blanchard.
3. James Burns.
4. John Dewey.
5. Peter Senge.

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