Systems Thinking

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Systems thinking is an evolving field, and there is growing demand to integrate systems thinking into many fields. As this demand increases, so does the need for and importance of identifying systems thinkers.

Keywords: systems thinking ; systems thinking characteristics ; systems thinker

1. Introduction

Frank [1] found that systems thinking has four distinct components: knowledge, personality traits, cognitive characteristics, and capability for engineering systems thinking [1]. He then developed the Capacity for Engineering Systems Thinking (CEST) questionnaire [2] as a tool for identifying systems thinking. Following the questionnaire's analysis, conducted previously by Kordova [3], researchers present here a new way of analyzing and categorizing the questions included in the questionnaire. According to the proposed division, each group of questions represents one component of systems thinking.

Analyzing the answers to the questionnaire makes it possible to identify which characteristics of systems thinking the respondent has and which he/she lacks. This facilitates assigning candidates to positions that require certain aspects of systems thinking or knowing which aspects of systems thinking must be learned.

The outcomes of the study will be of great benefit to different kinds of organizations from both low-tech and high-tech industries. Specifically, this research will benefit organizations in matching a candidate's systems thinking abilities with the right job. The significance of the study is reflected in the process of hiring employees, as well as in employee training processes.

2. Systems Thinking Characteristics and Abilities

Systems thinking is the ability to see a system as a whole and at the same time to identify that it is composed of interrelated components. The ability to identify the interrelationships and understand their impact on each other and on the entire system are essential qualities for a systems thinker. Systems thinking traits and the abilities needed to be a systems thinker can be divided to several categories. Senge [4] presented five areas in a learning organization: first, personal skills and a vision that defines the future portrait of the organization and how it can be achieved; second, mental models, including assumptions, generalizations, images, and embedded images that affect how people understand the world and the way they operate in it; third, the shared values, vision, and goals the organization wants to achieve; fourth, group learning that creates dialogue in the organization; and fifth, seeing the whole picture rather than focusing on details. Each of these areas has an impact on the systems thinking ability.

Frank [5] defined CEST as a concept. His various studies [5][6] outline the understandings and abilities required to be a systems thinker. The main cognitive abilities of CEST are seeing the big picture, knowing the internal relationships between the parts of the system, not going into detail, and having multidisciplinary and interdisciplinary knowledge. The ability to "see the forest and not the trees" is an important characteristic of systems thinking [7]. People who have an elevated vantage point, in terms of their perspective on the system and the ability to define which aspects should be considered and which can be ignored, are able to see both the trees and the forest. Frank [2] compared the previous studies that examined the traits required by a systems engineer and found that the ability to understand the system as a whole and see the big picture is a key factor in successful systems thinking. Von Bertalanffy [8] found that the same laws apply to different systems. Increased knowledge helps people to expand their ability for systems thinking. Checkland [9] proposed combining systems studies and using systems thinking in scenarios in which there is a conflict between the methods of natural science and highly complex phenomena, such as social problems that are not purely scientific. Zulauf [10] suggested that learning more about certain fields, including sociology, physics, and chemistry, would contribute to acquiring skills for systems thinking. Additionally, cooperative creation and design between countries are important for dealing with complex situations such as COVID-19 [11].

The internal connections between the components must be understood. The capabilities needed for systems thinking presented by Assaraf and Orion [12] include the need to identify the relationships between components. Yaffe [13] refers to the difficulty caused by not seeing the interrelationships. In many cases, only some parts are identified, while in other instances, they are identified incorrectly; as a consequence, the nature of the overall relationship between the parts and the whole system remains unclear. At times, insufficient attention is paid to the role played by each part of the system and to its contribution to the overall functioning of the system.

3. Developing Systems Thinking Abilities

The need for systems thinking is common to many disciplines, but the characteristics required for systems thinking in different areas or situations vary. It is important to identify the need for the specific characteristics in each situation and the relevant factors that influence systems thinking abilities in a specific context. Nagahi et al. [14] found that factors such as managerial level, the need for involvement in the environment, type of employer, and level of education have an impact on systems thinking abilities. However, Koral Kordova, Frank, and Nissel Miller [15] did not find a direct correlation between engineers' scores on systems thinking and the number of years of professional experience they had. Kordova and Frank [16] found that an engineering background does not have an impact on systems thinking, although Hung [17] did find that the combination of knowledge and practical experience helps people use systems thinking. Furthermore, practical experience and diversity of practice areas can contribute to acquiring systems thinking abilities [16][18][19]. Experience and a wide range of work issues, changes in positions, and familiarity with diverse technological systems can also improve engineers' capabilities for systems thinking [20].

According to Kim and Senge [21], systems thinking can be used when groups need to work, experience, and learn together. Valerdi and Zonnenshain [22] found that experience in engineering-based teamwork in a real work environment provides an opportunity to apply materials learned in a classroom. Assaraf and Orion [12] suggest that an outdoor learning environment can facilitate the learning process.

Richmond [23] noted that the ability to recognize familiarity in situations that initially appear different requires thinking that is operational and grounded in reality. In a study conducted by Kordova and Frank [24], experience gained in project implementation supported a significant improvement in CEST. Knowledge of the organization also helps develop systems thinking [25], as does thinking in closed loops that define circular and continuous processes with dependencies between them [23].

People's mental models influence their ability to correctly comprehend situations and make appropriate decisions when dealing with systems [26]. To reduce the effect of mental models, it is necessary to recognize them and then to find tools to avoid their impact. Lamb and Rhodes [27] explored the role of process and culture regulation in enabling or blocking systems thinking at the team and organizational levels. Documenting and correcting processes can help a group share mental models and overcome barriers that personal mental models pose in solving problems.

4. The Different needs of Systems Thinking

A hierarchical organizational structure makes it difficult to learn new things [28], and managers should already be skilled in systems thinking before reaching a managerial role. Managers in a system may implement team-building initiatives, such as cross-functional teams, cross-designation teams, and self-management teams, to overcome problems arising from the organizational hierarchy [29]. The systems engineering model of Kasser and Hitchins [30] stresses that each level in an organization should connect to and influence the levels above and below it. Levy [31] proposes a three-stage approach for managers acquiring systems vision: vertically, for team management that includes management and upward influence; horizontally, for lateral management across the organization; and outward to colleagues, partners, and systems leadership outside of the organization's boundaries. This way, managers can have "upward" influence and affect their agendas.

Market behavior is complex and prone to changes. Examining the market with systems thinking tools can help cope with both complexity and dynamism. Understanding how the market behaves as a system and creating collaborative value involves multiple players and resources [32]. People involved in private and public partnership projects need to think in new ways that reflect the timeline, complexity, and interdependence of the project [33]. Haas et al. [34] found that even fifth-grade students can be taught systems thinking practices if the right pedagogical model is found. Monat, Amissah, and

Gannon [35] suggest creating the philosophical and theoretical framework of a scientific school or discipline to help use systems thinking in a business environment.

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