ERNANE ROSA MARTINS
(ORGANIZADOR)

A CIÊNCIA DA COMPUTAÇÃO E O DESENVOLVIMENTO DE CONTEÚDO TECNOLÓGICO RELEVANTE PARA A SOCIEDADE

Atena Editora
Ano 2020

ERNANE ROSA MARTINS
(ORGANIZADOR)

A CIÊNCIA DA COMPUTAÇÃO E O DESENVOLVIMENTO DE CONTEÚDO TECNOLÓGICO RELEVANTE PARA A SOCIEDADE

Atena Editora
Ano 2020

2020 *by Atena Editora*
Copyright © Atena Editora

Editora Chefe: Profª Drª Antonella Carvalho de Oliveira
Diagramação: Natália Sandrini de Azevedo
Edição de Arte: Lorena Prestes
Revisão: Os Autores

Dados Internacionais de Catalogação na Publicação (CIP)
(eDOC BRASIL, Belo Horizonte/MG)

C569 A ciência da computação e o desenvolvimento de conteúdo tecnológico relevante para a sociedade [recurso eletrônico] / Organizador Ernane Rosa Martins. – Ponta Grossa, PR: Atena, 2020.

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui bibliografia
ISBN 978-65-86002-68-3
DOI 10.22533/at.ed.683202003

1. Computação – Pesquisa – Brasil. 2. Sociedade e tecnologia. I. Martins, Ernane Rosa.

CDD 004

Elaborado por Maurício Amormino Júnior – CRB6/2422

Atena Editora
Ponta Grossa – Paraná - Brasil
www.atenaeditora.com.br

Atena Editora
Ano 2020

APRESENTAÇÃO

A Ciência da Computação estuda as técnicas, metodologias e instrumentos computacionais, visando automatizar os processos e desenvolver soluções com o uso de processamento de dados. Este livro, se propõe a permitir que seus leitores venham a conhecer melhor o panorama atual da Ciência da Computação no Brasil, assim como, os elementos básicos desta ciência, por meio do contato com alguns dos conceitos fundamentais desta área, apresentados nos resultados relevantes dos trabalhos presentes nesta obra, realizados por autores das mais diversas instituições.

A Ciência da Computação, proporciona inúmeros benefícios para a sociedade moderna, tais como: a criação de empregos, o desenvolvimento de novos equipamentos, o ganho de produtividade nas empresas e o acesso à informação. Os estudos desta área são aplicados em diversas outras áreas do conhecimento, proporcionando a resolução de diferentes problemas da sociedade, sendo assim, cada vez mais estes profissionais são valorizados e prestigiados no mercado de trabalho. As empresas enxergam atualmente a necessidade de profissionais cada vez mais qualificados nesta área, a fim de que possam promover ainda mais inovação, desenvolvimento e eficiência.

Dentro deste contexto, este livro aborda diversos assuntos importantes para os profissionais e estudantes desta área, tais como: a utilização das Tecnologias de Informação e Comunicação (TIC's), a acessibilidade na web, a simulação por eventos discretos, as metodologias ativas, as técnicas de Data Mining, os Objetos Digitais de Aprendizagem (ODA), o uso do *Facebook* como interface didático-pedagógica, a aprendizagem colaborativa, os Sistemas de Informação Social, e a avaliação de softwares educativos, como por exemplo, a ferramenta Alice.

Sendo assim, os trabalhos apresentados nesta obra, permitem aos leitores analisar e discutir os relevantes assuntos abordados, tendo grande importância por constituir-se numa coletânea de trabalhos, experimentos e vivências de seus autores. Espera-se que esta venha a ajudar tanto aos alunos dos cursos de Ciência da Computação quanto aos profissionais atuantes nesta importante área do conhecimento, a enfrentarem os mais diferentes desafios da atualidade. Por fim, agradeço a cada autor, pela excelente contribuição na construção deste livro, e desejo a todos os leitores, uma excelente leitura, repleta de boas, novas e significativas reflexões sobre os temas abordados, e que estas possam contribuir fortemente no aprendizado.

Ernane Rosa Martins

SUMÁRIO

CAPÍTULO 8

SOCIAL INFORMATION SYSTEMS: AN APPROACH TO COMPLEXITY

Data de aceite: 18/03/2020

Jeferson Gonçalves de Oliveira
ORCID: https://orcid.org/0000-0003-4936-5820
Lattes: http://lattes.cnpq.br/8259411388327731
Filiação: Universidade FUMEC, Faculdade de Ciências Empresariais, Doutorando do Programa de Pós-Graduação em Sistemas de Informação e Gestão do Conhecimento
E-mail: jeferson.oliveirabh@gmail.com
Contribuição: concepção, desenho e desenvolvimento do artigo

Cristiana Fernandes De Muÿlder
ORCID: https://orcid.org/0000-0002-0813-0999
Lattes: http://lattes.cnpq.br/0450255381559550
Filiação: Universidade FUMEC, Faculdade de Ciências Empresariais, Professora Doutora do Programa de Pós-Graduação em Sistemas de Informação e Gestão do Conhecimento
E-mail: cristiana.muylder@fumec.br
Contribuição: revisão e aprovação final do artigo

Marta Macedo Kerr Pinheiro
ORCID: https://orcid.org/0000-0001-5592-3396
Lattes: http://lattes.cnpq.br/9006683778296973
Filiação: Universidade FUMEC, Faculdade de Ciências Empresariais, Professora Doutora do Programa de Pós-Graduação em Sistemas de Informação e Gestão do Conhecimento
E-mail: marta.macedo@fumec.br
Contribuição: revisão e aprovação final do artigo

Ana Maria Pereira Cardoso
Lattes: http://lattes.cnpq.br/9737143632051924
Filiação: Universidade FUMEC, Faculdade de Ciências Empresariais, Professora Doutora do Programa de Pós-Graduação em Sistemas de Informação e Gestão do Conhecimento
E-mail: ana.cardoso@fumec.br
Contribuição: revisão e aprovação final do artigo

Este artigo faz parte da Tese de Doutorado do Programa de Pós-Graduação da Faculdade de Ciências Empresariais da Universidade FUMEC. Autor: Jeferson Gonçalves de Oliveira - Título: Sistemas de Informação em Saúde: do pensamento complexo à inovação social. Ano de defesa: 2019

ABSTRACT: Information Systems have often been cited as solutions to solving social problems. However, like so much of modern science, they have been victims of reductionist and mechanistic thoughts, which point to it as a strictly technological solution. Due to this, several implementation attempts end in failure, reducing its system life cycle until its early discontinuity. The motivation of this paper was to contribute to the academic community on the development of a new approach to Social Information Systems, since it permeates a complex and dynamic social environment that transits between order and disorder constantly. For this purpose, a review of the literature was made in order to identify its characteristics and

its role in the organization of a complex social environment. As a result, it is observed that it must adhere to the principles of complexity theory to minimize entropy and delay systemic disorder. It is concluded, therefore, that the Social Information System is inseparable from the external environment, because it provides an interrelationship of its elements, and that the semantic load of information, the informational role of people and the wide exchange of information with the environment are key elements in favor of social transformation.
KEYWORDS: General Theory of Systems, Information Theory, Cybernetic Theory, Social Information Systems; Complexity.

SISTEMAS DE INFORMAÇÃO SOCIAL: UMA ABORDAGEM ADERENTE À COMPLEXIDADE

RESUMO: Os Sistemas de Informação têm sido apontados frequentemente como soluções para a resolução de problema sociais. No entanto, assim como grande parte da ciência moderna, têm sido vítimas de pensamentos reducionistas e mecanicistas, que o apontam como uma solução estritamente tecnológica. Com isso, várias tentativas de implementação acabam em fracasso, reduzindo o seu ciclo de vida do sistema até a sua descontinuidade precoce. A motivação deste trabalho foi contribuir para a comunidade acadêmica sobre o desenvolvimento de uma nova abordagem para os Sistemas de Informação Social, visto que este permeia um ambiente social complexo e dinâmico, que transita entre a ordem e a desordem constantemente. Para isso, foi feita uma revisão da literatura com o intuito de identificar as suas características e o seu papel acerca da organização de um ambiente social complexo. Como resultado, observa-se que ele deve ser aderente aos princípios da teoria da complexidade para minimizar a entropia e retardar a desordem sistêmica. Conclui-se, assim, que o Sistema de Informação Social é indissociável do meio externo, pois propicia a inter-relação dos seus elementos, e que a carga semântica das informações, o papel de elo informacional das pessoas e a ampla troca de informação com o ambiente são itens fundamentais para favorecer a transformação social.
PALAVRAS-CHAVE: Teoria Geral dos Sistemas, Teoria da Informação, Teoria Cibernética, Sistemas de Informação Social; Complexidade.

INTRODUCTION

"Complex" derives from the Latin word *complexus*, meaning "that which is woven together". Complexity can be defined as a tissue of actions, retroactions, determinations, hazards that constitute the phenomenal world (Morin, 2015). This leads to the conclusion that the different parts fit together to make up a whole, inserted in a context which involves the contradictions of dialogue, enabling us to learn about complex phenomena.

Currently, information systems (IS) have become indispensable parts to solve modern problems. However, recent studies on the subject have a focus on technological emphasis, with several gaps for the insertion of complex social contexts (Klein; Myers, 1999). The terms “systems” and “information” refer to theories that cannot be reduced to simple technological explanations.

Therefore, the Social Information Systems (SIS), amidst a complex social environment, must, as social technologies, provide or facilitate social innovation (Medeiros et al., 2017). It is observed, then, that the classic schemes of information systems - considering only the input, processing, and output - may be considered insufficient to minimize the impending entropy (disorder) of IS against the environment it represents.

In a broader context, Information Systems have many reference disciplines such as mathematics, logic, philosophy, sociology, psychology, and management, from which the theoretical bases are formed and adapted (Gregor, 2002). Another striking feature of IS relates to the use of artifacts in human-machine systems, where the inclusion of knowledge of the properties of physical objects (machines) and the knowledge of human behavior inseparably is required (Gregor, 2002b).

Seeking to deepen the subject of this relationship, from a literature review, we sought to answer the question: what are the characteristics of an SIS and what is its role in the organization of the complex social environment? Since the focus was to analyze the characteristics of an SIS in the organization of the complex social environment, the intention was specifically to: i) revisit the general systems theory, information theory, cybernetics theory and complexity theory; ii) prepare a social information system scheme connected to the encountered principles.

Understanding that several information systems implementations have often failed by reducing its life cycle, i.e. its early discontinuity (Heeks, 2006) and hoping to contribute to the enrichment of information on the information systems in a systemic and holistic manner, justifies the performed study.

Subsequently, we present the systemic paradigm, information and entropy, the principle of feedback, complex systems, the new approach to social information systems and closing remarks.

THE SYSTEMIC PARADIGM

According to Capra (2006), the biologist Ludwig von Bertalanffy is recognized as the first author who formulated a theoretical framework about the principles of organization of living systems. However, the Russian Alexander Bogdanov, little known outside of Russia, created a theory called “Tectology”, derived from the Greek “Tekton” meaning construction and can be translated as “science of structures.” The main objective of Bogdanov was to clarify and generalize the principles of organization of all living and non-living structures, i.e. create a universal science of organization (Capra, 2006).

However, it was the conceptions of Bertalanffy on open systems and a general systems theory, which leveraged the systemic thought as a scientific movement of first magnitude, especially with the strong support coming from Norbert Wiener with the cybernetic theory (Capra, 2006). He devoted himself to replacing the mechanistic foundations with a holistic view and stated that the theory is a general science of “wholeness”, considered until then a vague and nebulous concept. In an elaborate form, it could be described as a purely formal mathematical discipline, but applicable to various empirical sciences. As for the sciences concerned with “organized wholes,” it would have an importance similar to the probability theory in relation to the sciences that deal with random events (Bertalanffy, 1969).

Aldwin (2015) mentions that complex systems can be understood in terms of nodes and connectors, such as atoms or people. These connections between the nodes are not random, but reflect significant patterns. There are also nodes called hubs, which have multiple connections and can shorten distances between any set of nodes.

The theories considered classic, follow mathematical principles and are superior to simple reductionist models, as they are responsible for complex interactions between the elements of a system and make clear predictions of how change occurs. However, they are still largely deterministic (Witherington, 2014). In a more present-day vision, systems can also be considered holistic units of social networks, i.e. they are processes organized into hierarchies, both structural and functional, and interact with other systems. Moreover, they are dynamic, complex and evolve over time (Mobus; Kalton, 2015).

Morin (2015) states that systems theory has some important virtues: having placed a complex unit in the center of the theory, i.e., a whole that cannot be reduced to the sum of its constituent parts; having conceived the notion of system as ambiguous and fantastic; being situated at a transdisciplinary level, being wider than cybernetics in a range that extends to all knowledge.

Finally, the general systems theory, called a general science of wholeness, recognized that living organisms are open systems that cannot be described by the laws of classical thermodynamics. The so-called open systems need to be fed by a continuous flow of matter and energy extracted from their environment to stay alive, minimizing what is called “entropy” (Capra, 2006).

INFORMATION AND ENTROPY

Araújo (1995) mentions that everything is made of energy. From contours, shapes, movements, plants, animals, machines, everything in the world, from the simplest to the most complex. All that is manufactured or not by man is energy transformation from one state to another. The first law of thermodynamics states that energy is neither generated nor destroyed, it is simply transformed.

Outlined by Carnot and formulated by Clausius (1850), the second law of thermodynamics introduces the idea of energy degradation. The theory confirms that, although all forms of energy manage to be totally transformed, the ones which take on the calorific form cannot be fully reconverted, thus losing part of their suitability for a certain job. This irreversible reduction in the predisposition to transformation was called “entropy” (Morin, 2016). Briefly, entropy can be defined as energy loss or dissipation, disorder.

Claude Shannon in 1949, was the first to use the concept of entropy with information. In this study, he showed that information can be studied regardless of its semantics and proved that it can be successfully transmitted even with interference or noise. When defining the importance of information, Araújo (1995) describes:

> The information, in fact, is essential for all human activity, being increasingly seen as an important and powerful force as to give rise to expressions such as the information society, information explosion, the information age, information industry, information revolution, post-information society. Research on the entity information and its impacts is performed in different areas and contexts: its borders go beyond the human context and even the social one; permeating the animal and the machine, even being a philosophical category or related to philosophical categories such as matter, space, movement, time, and energy (Araújo, 1995, p. 3).

Shannon also stated that information is transmitted by a channel and it finds noise along its path, and may incorporate, to the signal, things that were not intended by the source (Shannon; Weaver, 1963). Through these statements, the Shannonian theory makes it clear that the information degradation is inherent to communication (Morin, 2016).

So, for a self-organizing system, it shall be opened, where the formation of structures and functions requires exchanges of energy, information, and matter with its surroundings (Haken; Portugali, 2016). Self-organization can be implemented by continuous exchange of information, where populations of individuals self-organize and coordinate a certain behavior (Santos et al., 2016).

Open systems are considered natural and perform constant exchanges with the environment, remaining in a stable state, avoiding the increase of entropy, and developing toward the order and organization states (Bertalanffy, 1969). Whereas the closed systems are isolated from their environment, and according to the second principle of thermodynamics, tend to get into disorder due to the entropy (Bertalanffy, 1969). Thus, in the open system, there is an imbalance in the energy flow that feeds it, and without this flow, there would be organizational disorder that would quickly lead to wilting (Morin, 2015).

However, in addition to environmental information, a system can use its own information in a process called feedback, correcting thus its own actions to minimize the effects of entropy.

THE FEEDBACK PRINCIPLE

Driven by World War II, the cybernetic theory promoted a socio-cultural and philosophical revolution, not limited only to the technological field. However, supported by a core of fully interdisciplinary work, contributed to the emergence of other sciences such as Cognitive Science, Artificial Intelligence, Robotics and Information Technology (Chaves, 2016).

The basic principle of cybernetics is that a system can use information to feed it back and thus correct its own actions. This is the equivalent of a kinesthetic sense known as feedback (Wiener, 1950). Thus, the feedback is a process where information circulates, is modified, then returns in order to influence the originator's behavior, either positively or negatively (Aritua et al., 2008).

This principle leads to circularity, that is, part of the output is directed back to the process as input, as regulatory mechanism or homeostasis. Homeostasis is the maintenance of a steady state or equilibrium, maintaining the integrity of the system in response to external disturbances. This control also requires a goal or an objective to which possible deviations are referred, and to which corrective expedients are forwarded (Salles, 2007).

Norbert Wiener, the father of the cybernetics theory showed that, through feedback, the system compensates for the environmental inputs and can achieve the goals of survival by reducing the entropy. Wiener unfolds his ideas on the subject based on the second law of thermodynamics:

> As the entropy increases, the universe and all closed systems in the universe tend to deteriorate naturally and lose its distinction [...]. But while the universe as a whole [...] tends to exhaust, there are local enclaves whose direction seem opposite to the universe in general and in which there is a limited and temporary tendency for organization to increase (Wiener, 1988, p. 12).

Another key feature of the systems-oriented feedback is that it must be in contact with the outside world by the sense organs, which not only say what the existing circumstances are, but also enables the recording of the performance of their own tasks (Wiener, 1988). Thus, Wiener's (1988) theory shows that resistance to entropy and sensitivity to the environment are critical to the survival of the systems.

Luhmann (1999), although he agrees with part of Wiener's theory (1988), believes that the social environment is dominated by proliferating complexities, not by entropic forces. Thus, the complexity of the social environment encompasses an infinite horizon of possibilities of action and experience. In this case, the author disagrees with Wiener (1988) and cites that systems must disregard the environment, since they amplify imbalances in external relationships (Luhmann 2012).

In recent years, several studies, especially on social systems, point out the advantages of Luhmann's theory (Valentinov; Chatalova, 2014; Valentinov, 2014; Valentinov, 2017, Thonson; Valentinov, 2017). However, the concept of Luhmann (1999) is divided into four types of systems: non-living, living, psychic and social. Non-living systems cannot be classified as autopoietic, which produce themselves (Maturana; Varela, 2001). So, to maintain themselves, the non-living systems necessarily require the environment (Kunzler, 2004), a fact that makes, regarding this point, the theories of Wiener (1988) and Luhmann (1999) consonant.

This need for exchange of energy and system information with the external environment is one of the main characteristics observed in so-called "complex systems".

COMPLEX SYSTEMS

The complexity has an important academic acknowledgment and has been the subject of several studies in recent years in various areas of knowledge (Chae, 2014; Chettiparamb, 2016; Walton, 2016; Copelli et al., 2016; Degener; Berne, 2017; Olya; Mehran, 2017; Efremenko et al.; 2018; Goldberg; Papadimitriou, 2018; Karatsanis et al., 2018; Mahajan; Saurabh, 2018).

Complex systems consist of the interaction of multiple stakeholders, objects and processes defined as a system based on interests or functions. In addition, they are unpredictable and maintain a state of balance constantly instantiated by importing, or input of energy from the environment around (Aritua et al., 2008). Thus, in complex systems, the interaction between the parts and the whole produce unpredictable behavior, a factor that makes it impossible for one of the parts to represent the whole (Gino, 2002).

Morin (2000b) points out the seven principles, complementary and interdependent, which support the theory of complexity. Some of them have been removed or improved, in this paper, from the theories cited above that apply to complex systems - general systems theory, information theory and cybernetics theory.

The first principle, called systemic or organizational, allows you to connect the knowledge of the parts to the knowledge of the whole and vice versa (Cilliers, 2000, Morin et al., 2003; Aritua et al., 2008). Morin et al. (2003, p.33) quotes a phrase by Pascal: “I find it impossible to know the parts without knowing the whole, as well as knowing the whole without knowing the parts.”

Since, from the systemic-organizational point of view, the whole is more than the sum of the parts, that “more than” points out qualitatively new phenomena called “emergencies”. (Cilliers, 2000, Morin et al., 2003; Aritua et al., 2008; Cairney, 2012). These are organizational effects, resulting from the disposition of the parts within the systemic unit. Thus, complex systems produce behavioral patterns and properties that cannot be predicted by the isolated knowledge of its parts (Cairney, 2012, Gallo, 2013; Gao et al., 2013).

The second principle, hologramatic, highlights the paradox of certain systems in which not only the part is in the whole, but the whole is also in the part (Morin, 2015). In this context, the reality must be perceived in an organizational form, connecting the events, individuals or other elements that become part of a global drive/unit?? with qualities that do not exist in separate parts (Morin, 2000).

The principle of the retroactive circuit, designed by Norbert Wiener, breaks the principle of linear causality. Araújo (2007) cites the difference between linear causality and the recursive one. The linear one is based on Cartesian thought, indicating a single method or a single way to do something. The recursive one indicates a dynamic and non-linear methodology, with the thinking open to the unexpected, the unknown and the random (Perrow, 2011). Thus, it is assumed that there is neither a beginning and not an end, and that every end is a new beginning and every beginning comes from a previous end.

The fourth principle, recursivity, is relative to the organizational recursion, “where products and effects are, at the same time, the producers themselves and the originators of what produces them” (Morin, 2000b, p.95). This principle goes beyond the retroactivity because it is more complex and rich, being essential for the design of self-production and self-organization, where the final states are needed for the generation of the initial states (Morin et al., 2003; Cairney, 2012). Thus, the complex systems tend to be composed of intelligent agents, which act and make decisions based on information of the entire system.

Whereas the principle of autonomy/dependence, introduces the idea of the self-eco-organizational process. According to Morin et al. (2003, p.36), “to maintain its independence, any organization needs the opening to the ecosystem which nourishes it, and to which it is transformed”. This autonomy is inseparable from this dependence as the organization needs to take energy, information and organization from its environment. Cilliers (2000) corroborate the principle and maintain that a complex system tends to have many interacting parts in a complex way, for which reason it is difficult to be dealt with.

The sixth principle, named dialogical, unites antagonistic principles that apparently should repel each other, but are inseparable and indispensable for the understanding of the same reality. Thus, the goal is contextualized, promoting the joints without eliminating the differences, connecting things that are apparently separate (Morin, 2015). “The dialogue makes it possible to rationally assume the inseparability of contradictory notions to conceive the same complex phenomenon” (Morin, 2000b, p.96). Thus, it must design a dialogic order/disorder/organization that is constantly at work in the physical, biological, and human worlds.

Regarding the latter principle, the reintroduction of knowledge within all knowledge, we consider operating and restoring the subject, revealing the central cognitive problem: “from the perception to the scientific theory, all knowledge is a reconstruction/translation by a mind/brain in a culture and at a certain time” (Morin et al., 2003, p.96). This refers to an epistemological analysis.

Based on some of these principles, Morin (2016) then suggests a tetralogical circuit where interactions are essential to the orderly organization. It is clear, then, that the more the order and organization are developed, the more they become complex and dependent even on the disorder. In addition, the interactions are reciprocal actions of order, disorder and organization occurring in a complementary, competing and antagonistic manner, simultaneously.

Thus, in order to have organization, there must be interactions; in order to have interactions, there must be encounters; in order to have encounters, it is necessary to have disorder (agitation, turbulence). This means that disorder, order, and organization, are linked by interactions in a supportive ring in which each of these cannot be conceived outside the reference of the others, and in which there are complex relationships (Morin, 2016).

The tetralogical ring also means that the more the order and organization are developed, but become complex, the more they tolerate, use and need disorder, that is, these terms order / organization / disorder and interactions, develop mutually (Morin, 2016). Moreover, it is not a vicious circle, because by means of it irreversible transformations, geneses, and productions take place. Thus, it is not a perpetual motion, because there is always loss where a non-recovered partial disorder (Morin, 2016).

Thus, Morin (2016, p. 97-98) states that:

> There is and always will be, in time, a dimension of degradation and dispersion; no organized thing, no organized being can escape degradation, disorganization and dispersion. No living being can escape death [...]; all creation, all generation, all development and even all the information must pay to the entropy; no system, no being can be regenerated in isolation (Morin, 2016, p.97-98).

However, for a better understanding of tetralogical ring, it is necessary to revisit the concept of organization. Morin (2016) defines organization in this context as the arrangement of relationships between components or individuals, which produces a system (complex unit) equipped with qualities unknown to the components or individuals. It ensures stability regarding the system connections, ensuring that it can endure despite the random disturbances. Thus, any interrelationship provided with stability or regularity acquires an organizational feature and produces a system.

It is important to mention that complex thinking does not, in any way, oppose to clarity, order and determinism, it considers them inadequate and reinforces: “do not forget that reality is changing, do not forget that the new can arise, and in any case, it will arise” (Morin, 2015, p.83).

Thus, information systems, so far with predominant mechanistic theories, need an approach to the complex social scenarios.

SOCIAL INFORMATION SYSTEMS: DISCUSSIONS ON THE APPROACH

Araújo (1995) states that the names Information System (IS) and Information Retrieval Systems (IRS) are improper, inadequate, and inappropriate. The author justifies her statement as follows:

> Information is everything that amends structures, i.e., it only exists in the context of the completed action, i.e., the effective contact between a “message, a potential information etc.” and the user. However, the area, perhaps for lack of a consolidated view of the phenomena information and information systems, has adopted and popularized the IS and SRI designations, thus generating confusion between the object worked upon, that is, documents, texts and messages, and the possible effect of the content on the user, i.e., the information itself. Thus, the terminology that is being adopted (IS and SRI) follows the paradigmatic connotation of the areas of communication and information science with the pointed out appropriate restrictions of their impropriety. That said, information systems are those that aim to carry out communication processes (Araújo, 1995, p. 3).

Turban et al. (2006) show that the scheme of an information system (IS) should only consider the inputs, the processing, the outputs, and a feedback mechanism that uses only the outputs of the system itself as a regulatory mechanism. O’Brien (2004) also suggests the components of an IS as: inputs, processing, and outputs. These views are based on classic technological concepts, which feature the IS only as a tool separated from its environment, except for representation of users as people. They are based on self-contained systems which remain perpetually absolute and immutable (Morin, 2016).

Thus, most of the implementation of information systems theories are narrow and mechanistic, because it can only be understood as part of a broader social and organizational context (Klein; Myers, 1999). Later, with the moral and social revolution promoted by the systems theory, this view began to change with the application of complexity theory in the social sciences (Cairney, 2012; Chettiparamb, 2014).

The definition of Social Technology (ST) adequately illustrates this change. The ST can be described as techniques, materials and methodological procedures tested, verified, and validated and with evident social impact, which were prepared through a social need to solve a social problem. They are generally associated with improved quality of life and social inclusion (Lassance Jr.; Pedreira, 2004). Thus, it is observed that a Social Information System (SIS) is a type of ST.

Baumgarten (2006) shows that social technologies can be the basis of a broad network of social actors. At the same time, social innovation based on social technologies needs to be structured in a flexible model to suit different situations and contexts. Social technologies are therefore techniques, materials and methodological procedures tested, validated and with proven social impact created from social needs to solve social problems. They are considered complex and multifaceted, involving several actors and are, due to their nature, complex and difficult to solve.

Medeiros et al. (2017) corroborate this distinction and point out that social technology focuses on meeting needs presented by local communities, functioning as a tool that can generate social innovation. This, by causing diffusion and institutionalization of new practices, enables the social transformation.

Moreover, social innovation is new solutions (products, services, models, markets, processes, etc.) that meet simultaneously a social need, more effectively than previous solutions, and lead to skills and relationships improved through better use of resources and assets (Tepsie, 2012).

However, the social dimension is considered, from the systemic point of view, as highly complex with a feature of autopoiesis (Kunzler, 2004). According Morin (2016), this system develops mutually order / organization / disorder and interactions with losses and dispersion because no organization can escape degradation.

Thus, the SIS should be designed as an open system where information flows from the system to the outside and vice versa because, like any system, it is subject to entropy. For this purpose, the project must accept uncertainty (Montuori, 2013) and should be minimally prepared for a dialogue of order/disorder/organization. In this context, new information enters the loops of feedback and influences the system to adapt to the external environment (Aritua et al., 2008).

For this reason, the exchange of information with the external environment is essential to minimize the entropy of the SIS. In its negative form, feedback stabilizes the system and in its positive form, plays the role of an amplifying mechanism. The feedback, both regarding environmental data, and the data of its own output, are fundamental for the SIS to minimize the disorder and to be adherent to the complex system for a longer period of time.

Thus, complementing the retroactive principle, it is consonant with the principle of autonomy / dependence, where the SIS should be open to the ecosystem from which it is nourished. This autonomy is inseparable from this dependence, because the organization needs to remove information from its environment. For this reason, it is understood that the more the SIS permeates its environment, the lower its entropy. This means that it is recommended that it covers the largest number of nodes or potential actors of a complex social system, to promote the exchange of information with this environment.

In addition, only connecting all individuals or other elements of the complex system, it is possible that they compose a new global unit with non-existent qualities in separate parts (hologramatic principle). The more complex the external environment, the more agents and more connections SIS must support and connect, given also the systemic or organizational principle. This allows connecting the knowledge of the parts to the knowledge of the whole and vice versa, awakening behavioral patterns and properties that cannot be predicted by the knowledge of its isolated parts, called emergencies.

These considerations are consistent with Araújo (1995) regarding the recognition of entropy in information systems. However, the author shows that information systems are reaching their limits of growth and saturating, making the inversion of this exponential growth an essential condition for their survival as a social system.

In the case of social information systems, this paper shows that the SIS must be part of the interrelationship web to permeate the most the complex environment, thus minimizing the entropy of SIS and dispersion of the complex social system (order/disorder/organization).

This web of interrelationships provides recursion or recursivity, where the final states are needed for the generation of initial states (Morin et al., 2003). The SIS must be able to analyze the feedback data to present it to the environment, providing self-organization and thus, personalized regulation of the SIS generating specific data for the stakeholders involved.

To illustrate this new proposal, a new approach was developed for a Social Information System (Figure 1) based on the classic scheme of an IS added to the principles of complexity mentioned above:

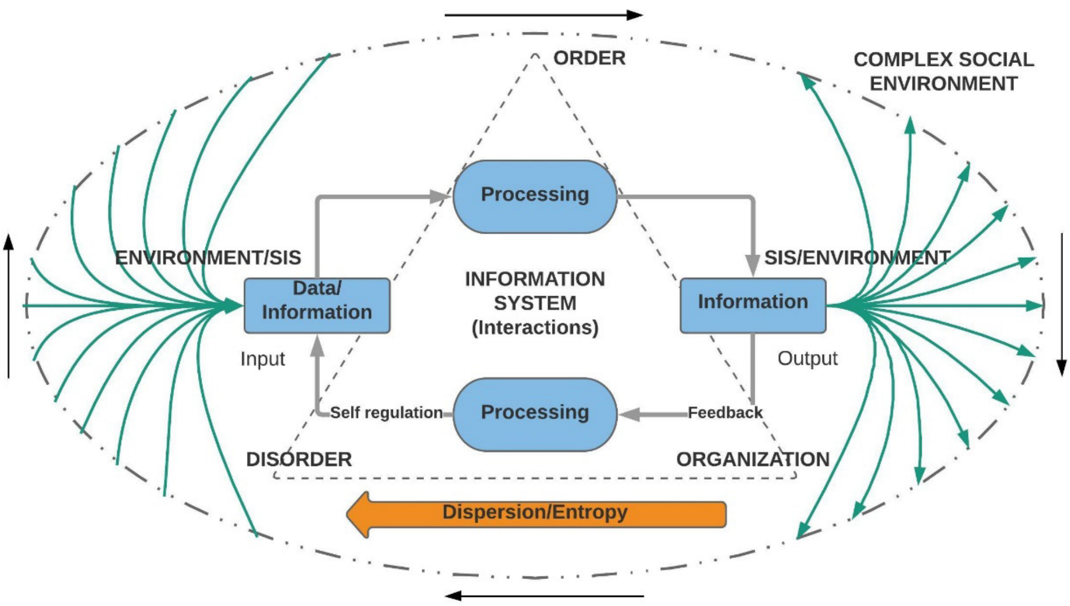

Figure 1. A new conceptual approach to social information systems

Font: prepared by the authors (2018).

In the designed model, the complex social environment surrounding the information system. This external system is dynamic and constantly involves periods of order / organization / disorder (represented by the dashed triangle and the outer arrows indicating movement) and in the transition moments of organization / disorder the dispersion of information occurs represented by the orange arrow.

During this process, the SIS consumes and provides information to the social environment, to minimize the entropy and provide a greater durability of organization in the external environment. For the same reason, it can use its outputs as feedback elements in a feedback movement. It is important that this is planned to interpret this information in the reentry of the system, allowing it to correct any errors or deviations of processes without necessarily a human intervention (self-regulation), since it happens naturally as an action coming from external environmental actors/ stakeholders.

However, this information must be provided with an adequate semantic load so that communication can be efficient because the complexity theory points out the Shannonian insufficiency of the bits: the important thing is not the amount of information but the information organization. The bit cannot measure a degree of organization, a degree of life or intelligence, nor can it reveal the factual / relational / improbable nature of the information (Morin, 2016). If this does not occur, the data processed by the SIS will not be returned as information, but just a “data” devoid of meaning.

Another important detail is relative to people. Turban et al. (2006) state that people are considered as one of the components of an information system. However, it is concluded that this statement is relevant but insufficient. People are also part of the complex social environment and are the informational SIS / Environment link, where both merge, and the SIS become part of the larger system. Thus, SIS and the social environment are inseparable, and the Social Information System a key part of the interactions of the tetralogical complex circuitry of the social environment.

This underlies the importance of an interdisciplinary approach in the development of an information system that includes the use of artifacts and human-machine systems that allow insertion of knowledge of the properties of physical objects (machines) and the knowledge of human behavior inseparably (Gregor, 2002b). This human behavior, in turn, is subjective and influenced by the social environment in which it is housed, reinforcing the complex character of the system.

CONCLUSION

There is a tendency to classify social innovation (SI) as a kind of technological innovation. However, this view has mostly been questioned by several problems that classical technological innovation cannot solve, such as poverty, the effects of climate change and the so-called "wicked problems". These are considered complex and multifaceted, involving multiple actors/stakeholders and are, by their nature, complex and difficult to solve.

Social innovation considers the product (meeting social needs), processes (improving relationships / skills and using resources and assets in a new way) and social empowerment dimensions (increasing the society's capacity to act). We can then observe a paradoxical scenario where social innovation is at the service of a social need, resulting in the empowerment of the population and in the improvement of systemic interactions through more effective use of resources. Thus, the improved capacity, which arises because of social innovation, has the characteristics of an "emergency" systems, i.e., a set of properties that could not be provided through isolated knowledge of the parts.

Concurrently, in the literature, information systems are discussed from a purely technological view, that is, from the point of view of information retrieval systems. This misunderstanding is the result of reductionist thinking that has dominated Western thought from the sixteenth and seventeenth centuries, consolidated by René Descartes (1642-1726). However, information systems theories can only make sense as part of a broader social and organizational context.

To review these concepts, this study sought to revisit the theories that support the systems, especially from the point of view of the complexity theory. We can then observe that a social information system is contained in a complex social environment that goes through constant periods of order/disorder/organization, i.e. period of chaos/non-chaos provided by the dialogic principle of complexity.

Thus, it is noted that the information system has complex characteristics and tends to suffer due to entropy until it comes into disuse early. Therefore, a social information system should have the features of an open system, i.e. exchange information with the complex social environment, forming a web of interactions that promote positive feedbacks, which have an amplifying character.

As a contribution, this paper complements the theory which shows that the entropy can be minimized by reducing the size of an information system, that is, reversing its exponential growth. Specifically, in the case of SIS, it is believed that this should permeate the entire complex network to achieve information exchange with the environment, using them in feedback processes and recursion.

However, a large amount of SIS / Environment interactions devoid of semantics, tends to cause disturbances in the social system, favoring the dispersion through noises that degrade the information and promote the disorder. This effect is contrary to the conclusion of this study, and the increase of interactions is one of the pillars to ensure the success of the SIS as a social technology.

In addition, considering that the organization depends on the interactions between system elements, it is concluded that an SIS is inseparable from the external environment as it enables the interrelationships, keeping it organized for a longer period of time against the inevitability of the disorder. This means that the entropy of the SIS implies disorder in the social system.

Complementarily, people play the role of informational link between the SIS and the external system as part of both the one and the other and favor the formation of a single and indivisible social system. It is felt that this link is an essential piece to ensure the system organization, and interdisciplinary actions are indispensable for this understanding.

We can thus conclude that the SIS is an important technology for social interactions of a complex social system, which, in turn, is essential to improve skills and relationships in social innovation. For this reason, it is observed that the semantic load of information, the role of informational link of people and exchanges of SIS information with the whole complex social environment are key items for the organization of this social system.

Although the methodology of the proposed article does not seek to exhaust the subject, and considering that it is limited by subjectivity, it suggests new studies that provide discussion about the relationship between the themes. As a future paper, we intend to verify, empirically, the relationships discussed in this study and that constitute the model.

REFERENCES

ALDWIN, C. M. How can Developmental Systems Theories Cope with Free Will? The importance of stress-related growth and mindfulness. **Research in human development**, v. 12, n. 3-4, p. 189-195, 2015.

ARAÚJO, M. M. S. O pensamento complexo: desafios emergentes para a educação on-line. **Revista Brasileira de Educação**, v. 12, n. 36, set./dez. 2007.

ARAÚJO, V. M. R. H. Sistemas de informação: nova abordagem teórico-conceitual. **Ciência da informação**, v. 24, n. 1, p. 54-76, jan./abr. 1995.

ARITUA, B.; SMITH, N. J.; BOWER, D. Construction client multi-projects–A complex adaptive systems perspective. **International Journal of Project Management**, v. 27, n. 1, p. 72-79, 2009.

BAUMGARTEN, M. Tecnologias sociais e inovação social. In: CATTANI, A.; HOLZMANN, L. (orgs.). **Dicionário de trabalho e tecnologia.** Porto Alegre: UFRGS, 2006.

BERTALANFFY, Ludwig Von. **General system theory**: Foundations, development, applications. New York: G. Braziller, 1969.

CAPRA, Fritjof; EICHEMBERG, N. R. **A teia da vida: uma nova compreensão científica dos sistemas vivos**. São Paulo: Cultrix, 2006.

CAIRNEY, Paul. Complexity theory in political science and public policy. **Political Studies Review**, v. 10, n. 3, p. 346-358, 2012.

CHAE, B. K. A complexity theory approach to IT-enabled services (IESs) and service innovation: Business analytics as an illustration of IES. **Decision support systems**, v. 57, p. 1-10, 2014.

CHAVES, V. H. C. **Norbert Wiener: a teoria cibernética de um matemático**. 2016. 157 f. Tese (Doutorado em Educação Matemática), Universidade Estadual Paulista, São Paulo, 2016.

CHETTIPARAMB, Angelique. Articulating 'public interest'through complexity theory. **Environment and Planning C: Government and Policy**, v. 34, n. 7, p. 1284-1305, 2016.

CHETTIPARAMB, Angelique. Complexity theory and planning: Examining 'fractals' for organising policy domains in planning practice. **Planning Theory**, v. 13, n. 1, p. 5-25, 2014.

CILLIERS, Paul. What can we learn from a theory of complexity?. **Emergence**, v. 2, n. 1, p. 23-33, 2000.

COPELLI, F. H. D. S.; OLIVEIRA, R. J. T. D.; OLIVEIRA, C. M. S. D.; MEIRELLES, B. H. S.; MELLO, A. L. S. F. D.; MAGALHAES A. L. P. O pensamento complexo e suas repercussões na gestão em enfermagem e saúde. **Aquichan**, v. 16, n. 4, p. 501-512, 2016.

DEGENER, Sophie; BERNE, Jennifer. Complex questions promote complex thinking. **The Reading Teacher**, v. 70, n. 5, p. 595-599, 2017.

EFREMENKO, K.; LANDSBERG, J., SCHENCK, H.; WEYMAN, J. On minimal free resolutions of sub-permanents and other ideals arising in complexity theory. **Journal of Algebra**, v. 503, p. 8-20, 2018.

GALLO, Giorgio. Conflict theory, complexity and systems approach. **Systems Research and Behavioral Science**, v. 30, n. 2, p. 156-175, 2013.

GAO, J.; LIU, F.; ZHANG, J.; HU, J.; CAO, Y. Information entropy as a basic building block of complexity theory. **Entropy**, v. 15, n. 9, p. 3396-3418, 2013.

GINO, Francesca. Complexity measures in decomposable structures. In: **EURAM 2nd Conference, Stockholm**, p. 9-11, 2002.

GOLDBERG, P. W.; PAPADIMITRIOU, C. H. Towards a unified complexity theory of total functions. **Journal of Computer and System Sciences**, v. 94, p. 167-192, 2018.

GREGOR, Shirley. A theory of theories in information systems. **Information Systems Foundations: building the theoretical base**, p. 1-20, 2002.

GREGOR, Shirley. Design theory in information systems. **Australasian Journal of Information Systems**, v. 10, n. 1, 2002b.

HAKEN, Hermann; PORTUGALI, Juval. Information and Selforganization: A Unifying Approach and Applications. **Entropy**, v. 18, n. 6, p. 197, 2016.

HEEKS, Richard. Health information systems: Failure, success and improvisation. **International journal of medical informatics**, v. 75, n. 2, p. 125-137, 2006.

KARAKATSANIS, L. P.; PAVLOS, G. P.; ILIOPOULOS, A. C.; PAVLOS, E. G.; CLARK, P. M.; DUKE, J. L.; MONOS, D. S. Assessing information content and interactive relationships of subgenomic DNA sequences of the MHC using complexity theory approaches based on the non-extensive statistical mechanics. **Physica A: Statistical Mechanics and its Applications**, v. 505, p. 77-93, 2018.

KLEIN, H. K.; MYERS, M. D. A set of principles for conducting and evaluating interpretive field studies in information systems. **MIS quarterly**, v.23, n. 1, p. 67-93, 1999.

KUNZLER, C. M. A teoria dos sistemas de Niklas Luhmann. **Estudos de sociologia**, v. 9, n. 16, p.123-136, 2004.

LASSANCE JR, A. E.; PEDREIRA, J. S. Tecnologias sociais e políticas públicas. **Tecnologia social: uma estratégia para o desenvolvimento. Rio de Janeiro: Fundação Banco do Brasil**, p. 65-82, 2004.

LUHMANN, Niklas. **Die Gesellschaft der Gesellschft. Suhrkamp**. Frankfurt am Main, 1999.

LUHMANN, Niklas. **Theory of Society.** Stanford CA: Stanford University Press, 2012.

MAHAJAN, Meena; SAURABH, Nitin. Some complete and intermediate polynomials in algebraic complexity theory. **Theory of Computing Systems**, v. 62, n. 3, p. 622-652, 2018.

MATURANA, H. R.; VARELA, F. J. **A árvore do conhecimento: as bases biológicas da compreensão humana**. São Paulo: Palas Athena, 2001.

MEDEIROS, C. B.; GALVAO, C. E. S.; CORREIA, S. E. N.; GOMEZ, C. R. P., CASTILLO, L. A. G. Inovação social além da tecnologia social: constructos em discussão. **RACE-Revista de Administração, Contabilidade e Economia**, v. 16, n. 3, p. 957-982, 2017.

MOBUS, G. E.; KALTON, M. C. **Principles of systems science**. New York: Springer, 2015.

MONTUORI, Alfonso. Complexity and transdisciplinarity: Reflections on theory and practice. **World Futures**, v. 69, n. 4-6, p. 200-230, 2013.

MORIN, Edgar; LE MOIGNE, Jean-Louis. **A inteligência da complexidade**. Tradução: Nurimar Maria Falci. São Paulo: Peirópolis, 2000.

MORIN, Edgar. **A cabeça bem-feita: repensar a reforma, reformar o pensamento**. Rio de Janeiro: Bertrand Brasil, 2000b.

MORIN, E.; MOTTA, R. D.; CIURANA, É. R.; PEREIRA, S.; LAGES, M. **Educar para a era planetária: o pensamento complexo como método de aprendizagem no erro e na incerteza humana**. 2003.

MORIN, Edgar. Tradução: LISBOA, Eliane. **Introdução ao pensamento complexo**. Porto Alegre: Sulina, 2015.

MORIN, Edgar. **O Método I: a natureza da natureza**. Porto Alegre: Sulina, 2016.

OLYA, H. G.; MEHRAN, J. Modelling tourism expenditure using complexity theory. **Journal of Business Research**, v. 75, p. 147-158, 2017.

PERROW, Charles. **Normal Accidents: Living with High Risk Technologies-Updated Edition**. Princeton university press, 2011.

SALLES, F. R. **A relevância da cibernética: aspectos da contribuição filosófica de Norbert Wiener**. 2007. 85 f. Dissertação (Mestrado em Filosofia) – Faculdade de Filosofia, Universidade de São Paulo, São Paulo, 2007.

SANTOS, F. P.; ENCARNAÇÃO, S.; SANTOS, F. C.; PORTUGALI, J.; PACHECO, J. M. An evolutionary game theoretic approach to multi-sector coordination and self-organization. **Entropy**, v. 18, n. 4, p. 152, 2016.

SHANNON, Claude E.; WEAVER, Warren. The mathematical theory of communication. 1949. **Urbana, IL: University of Illinois Press**, 1963.

TEPSIE. The Young Foundation, 2018. Disponível em: <https://youngfoundation.org/projects/tepsie/> . Acesso em: 15 dez. 2018.

THOMPSON, Spencer; VALENTINOV, Vladislav. The neglect of society in the theory of the firm: a systems-theory perspective. **Cambridge Journal of Economics**, v. 41, n. 4, p. 1061-1085, 2017.

VALENTINOV, Vladislav. The complexity–sustainability trade-off in Niklas Luhmann’s social systems theory. **Systems Research and Behavioral Science**, v. 31, n. 1, p. 14-22, 2014.

VALENTINOV, Vladislav. Wiener and Luhmann on feedback: From complexity to sustainability. **Kybernetes**, v. 46, n. 3, p. 386-399, 2017.

VALENTINOV, Vladislav; CHATALOVA, Lioudmila. Institutional economics and social dilemmas: a systems theory perspective. **Systems Research and Behavioral Science**, v. 33, n. 1, p. 138-149, 2016.

WALTON, Mat. Expert views on applying complexity theory in evaluation: opportunities and barriers. **Evaluation**, v. 22, n. 4, p. 410-423, 2016.

WIENER, Norbert. Cybernetics. **Bulletin of the American Academy of Arts and Sciences**, v. 3, n. 7, p. 2-4, 1950.

WIENER, Norbert. **The human use of human beings: Cybernetics and society**. Perseus Books Group, 1988.

WITHERINGTON, D. C. Self-organization and explanatory pluralism: Avoiding the snares of reductionism in developmental science. **Research in Human Development**, v. 11, n. 1, p. 22-36, 2014

ÍNDICE REMISSIVO

A

C

D

E

G

I

L

Atena
Editora
2020