Introduction

Systems thinking has played a very important role in initial attempts to comprehend the interconnectedness existing between the natural and the social worlds and in challenging the view that humans are intrinsically superior to other biological entities and are thus the “masters” of nature. Many social and health problems have been addressed, including the eradication of illnesses and improvements in food production, through effective systemic interventions. Paradoxically, systems thinking came to prominence during the Second World War (Christopherson and Baughan 1995), playing an important role in the development of the postwar chemical and nuclear industries and economies and in the creation of national health services in the UK and elsewhere. The publication of Churchman et al. (1957) Introduction to Operations Research is considered an important reference for these practical applications.

However, it was the work of biologists von Bertalanffy’s (1968) General Systems Theory, Maturana and Varela’s (1980) Autopoiesis and Cognition, and Churchman’s (1979) The Systems Approach that clarified certain aspects of systems’ behavior; they used concepts such as “feedback,” “self-regulation,” and “emerging properties” in understanding the complexity of social systems. Their ideas allowed new generations of social and natural scientists to frame the relationship between humans and the natural world as being based on “co-dependency” and “coevolution,” rather than on a narrow understanding of the Darwinian concepts of “competition” and the “survival of the fittest.”


Systems thinking has also informed ethical debates on the exploitation of natural resources, biodiversity, and economic and social development and discussions on animal rights and climate change and has contributed to the exploration of ethical frameworks found in Asian, African, Latin American, and ancient cultures. Systemic (holistic) thinking must be at the center of the design and implementation of solutions to achieve existing Sustainable Development Goals (SDGs).
Furthermore, it will allow meaningful interaction and synergy among those working toward individual goals to the benefit of communities worldwide and the natural environment.

**Systems Thinking**

A systemic approach to natural and social phenomena is characterized by its focus on interrelationships, dynamic processes, and on the outputs (both intended and unintentional) that emerge from the interaction of different single elements and clusters of elements, as perceived by an observer. Systems can also be seen as dynamic mental constructs that behave as if they had some purpose. In this sense, at the core of a systemic approach lies a process of **boundary definition**: a sense-making cognitive process that simultaneously includes and prioritizes (a system’s elements and processes) and excludes (its environment or background) – although there is some degree of interaction across the boundary. It is the boundary definition that provides the system’s identity and differentiation from its context.

The interest in understanding and improving a situation that is perceived as dynamic and problematic is often an important drive toward developing systemic models. However, improving an element or a cluster of elements (sub-system) in isolation could create unintended consequences in other areas of the system or in its environment. Examples include the unrest and chaos that could result from the swift fall of a head of state whose removal was considered by political opponents as highly desirable to solve certain problems in a political system; the sudden introduction of tariffs to protect a local industry which in turn causes the total collapse of exports and livelihoods elsewhere; or the sending of surplus food products, textiles, and footwear, as a part of well-intentioned aid packages that adversely influences fragile industries in developing economies. In this context, it is easy to appreciate that systems thinking interventions reflect cultural, technical, political, and economic interests, opportunities and constraints, ideology, power, and ethics.

**The System**

A system gathers a group of components (elements and relationships) in an organized manner (Valero-Silva 2017); these components are interdependent, which means that they would behave differently if removed from the system, such as when a bodily organ stops interacting with other organs or is extracted from a living organism; when a particular species becomes extinct or is removed from its habitat; or when members of a community are displaced by war or climate change.

In a similar manner, systems produce outputs as a result of certain processes and can, to a certain degree, self-regulate internally through using negative feedback mechanisms (homeostasis). Examples include changes in blood pressure, sugar levels, or body temperature, modifying interest rates in a volatile housing market, the banning of certain chemicals to restore atmospheric ozone levels, and the issuing of work visa systems to address manpower shortages. Systems also exhibit emerging properties that cannot be explained by analyzing individual components or processes, such as life, happiness, well-being, or climate change. This is exemplified in the famous expression attributed to the Greek philosopher Aristotle: “the whole is greater than the sum of its parts.” Although changes in the system do not necessarily assume the dissolving of the system into its background, it is always surprising to see how, due to gaps in our understanding, small unexpected changes inside the system itself or within its environment may trigger a range of results: great improvements or the dissolution of an entire natural or social system through a “positive feedback” mechanism (snowball effect), such as those that produce a “bank run” or a share price collapse.

This leads to the distinction between open systems, those with important interactions with their environment (e.g., social systems), and closed systems whose interactions with their environment are not relevant to addressing the issues considered. Furthermore, certain systems, such as living cells, are able to use raw materials to produce their own components and to reproduce
and maintain themselves (autopoiesis), within certain environmental parameters.

In this context, some systems thinkers believe that the most important boundary to consider must be placed around the planet Earth – including its atmosphere and the artificial satellites placed in orbit (that have/could become space litter). This approach is known as the Gaia theory (Lovelock 1979, 2006); it assumes the planet Earth as a dynamic collection of living and nonliving elements and processes in constant interaction. It highlights that within certain parameters, the planet is able to support life over millennia through highly complex self-regulatory mechanisms, such as coevolution, natural selection, extinctions, tectonic movements, and weather patterns. Gaia theory demonstrates how human action could alter the planet’s self-regulatory mechanisms, thus threatening the possibility of life as we know it; examples include the industrial use of pesticides (Carson 1962) and population growth (Fisher et al. 2013). The interconnectedness of these processes was illustrated by Lorenz’s (1972) butterfly effect metaphor: “Does the flap of a butterfly’s wings in Brazil set off a tornado in Texas?”

**From Hard to Critical Systems Thinking**

A clear typology has been used to classify systems and systems thinking in the literature: “hard systems” are systems with very clear objectives, usually achievable by modelling. This is to say, there is a known current state (S₀), a desired state (S₁), and a series of routes to take the system from S₀ to S₁; the role of the systems analyst is to choose the optimum route within certain parameters. Hard systems are very common in engineering-type structured situations using simulation testing models and influence diagrams. “Soft systems,” on the other hand, are those representing problematic unstructured situations, emerging from different perspectives advocating for alternative boundary definitions. Checkland (1981) developed his soft systems methodology (SSM), aimed at addressing these situations, based on the concept of the respective Weltanschauung (worldview) of those involved as represented in rich picture diagrams. SSM shares elements of action research (Lewin 1946; Reason and Bradbury 2006) and participatory action research (Freire 1970; Fals-Borda 2006). Some systems practitioners have also applied elements of hard systems modelling and soft systems in what is called soft operational research “Soft OR” (Forrester 1994; Rosenhead and Mingers 2001). Others have focused on the relationship between systems and sub-systems at different levels to ensure their overall survival and autonomy in a changing environment; these use concepts such as regulation, recursion, communication, and control in what is generally called organizational cybernetics VSM (Beer 1995, 2003). Finally, “critical systems thinking” aims at addressing ethical (Ormerod and Ulrich 2013) and moral considerations linked to the process of boundary definition; examples include Ulrich’s (1983, 1995) work on “boundary judgments” and “boundary critique” inspired by his collaboration with C.W. Churchman and explorations into systems thinking and poststructuralism (Valero-Silva 2000). Certain pragmatic systems practitioners use a combination of these approaches through which to address real-life situations (Jackson 1991). The next sections will explore how systems thinking has effectively addressed pressing social/natural issues, such as industrialization and consumerism, and how systems, when left unchecked, can also produce undesirable and unintended consequences.

**Systems Thinking and Industrialization**

Serious concerns about the effects of industrialization, urban living, and environment have long been expressed. Examples include the cholera epidemics in London linked to drinking water being contaminated with human sewage in the 1850s and the effects of the widespread use of coal as fuel that culminated in the severe smog episodes that affected St. Louis (USA) in 1939, Donora (USA) in 1948, London in 1952, and New York in 1953. These events were linked to thousands of premature deaths and serious
illnesses. The power of systemic (holistic) thinking in explaining the causes of these problems and the contribution of industry in providing new products (e.g., “cleaner” varieties of coal) and of engineering by improving civil works were perceived as the undisputed tools necessary to achieving both social and economic developments and particularly improved health.

More recently, the chemical and pharmaceutical industries, together with decisive international action led by the UN and the World Health Organization (WHO), were also seen as a powerful combination that would address certain world problems in a systemic manner. There were the fight against smallpox that began in 1958, which culminated in its eradication in 1979, and the development and widespread use of high-yielding varieties of cereals and grains that, with the use of pesticides and improved irrigation techniques, has since the 1940s saved millions from starvation in the Third World – an initiative called the Green Revolution. These are very good examples of the synergy that can be generated between scientific and social systems and models when they combine to address global issues.

However, events such as the publication of Rachel Carson’s *Silent Spring* in 1962 that highlighted the negative effects of the indiscriminate use of pesticides in the environment; the powerful images broadcast by the media of the devastation caused by the use of chemical weapons during the Vietnam War, including the photographs of the conflict taken by Nick Ut; the threat of nuclear war; the youth and social movements in the USA and in Europe; and the creation of Greenpeace in 1971 challenged the underlying systems models that supported the chemical and nuclear industries – and the lack in their system designs of the inclusion of long-term social and environmental impact considerations. Finally, the recent heightened awareness of the devastating and long-lasting effects of plastic pollution on soil/water and on the marine environment has brought the production and use of plastics in general, and single-use plastics in particular, to the forefront of efforts to protect the environment (BBC 2018). These factors challenged the boundaries of the systems used by science and economics; also, they highlighted the dangers potentially posed by science, technology, and industry when left both unchecked and at the mercy of political and economic interests that had not fully been appreciated. A new era of environmentalism has begun, challenging the image of humans as the masters of the planet and questioning the perceived “neutrality” of current industrial and economic systems.

**Systems Thinking and Consumerism**

Consumerism, and its related term affluenza, has been widely discussed in the context of sustainability. It is broadly applied to the compulsive acquisition of products and services not needed to satisfy basic human needs and to the disposal of still-functioning products to acquire new ones that offer the same or a very similar function. These behaviors are supported by an addiction to economic growth systems, the availability of cheaper products, marketing, and financial systems in the form of credit. In this sense, the term “conspicuous consumption” was firstly used by the economist Thorstein Veblen in his 1899 book *The Theory of the Leisure Class* (reprinted in 1994), referring to the behaviors and attitudes to wealth of the nouveau riche. Thus, products are bought, for example, to satisfy hedonistic values such as fantasies and fun (Holbrook and Hirschman 1982) and status and wealth display, as a proof of success and as a transfer mechanism to compensate for a variety of mild and serious psychological disorders.

Other areas of exploration regarding consumerism include the relationship between consumerism and identity, as explored by Williamson (1978), who states that “the conscious chosen meaning in most people’s lives comes from what they consume”; the relationship between advertising and desire/satisfaction as highlighted by Taylor and Saarinen (1994), who argued that “desire does not desire satisfaction. To the contrary desire desires desire. The reason images are so desirable is that they never satisfy”; and, finally, the understanding of the consumer as an active agent in the construction of meaning (Elliott 1997).
However, consumerism has also been promoted as an important element of developmental and economic systems in Western capitalist societies. For example, Paul M. Mazur, an investment banker and partner at the now bankrupt Lehman Brothers, introduced the concept of “obsolescence” to the Advertising Club of New York in 1928 as “wear alone” was too slow for the needs of the American industry: “if what had filled the consumer market yesterday could only be made obsolete today, that whole market would be again available tomorrow” (Slade 2007, p. 60).

In the same year, Justus George, then editor, introduced the concept of “progressive obsolescence” in the trade journal Advertising and Selling: “we must introduce people to buy a greater variety of goods on the same principle that they now buy automobiles, radios, cloths, namely: buying goods not to wear out, but to trade in or discard after a short time… buying for up-to-dateness, efficiency, and style, buying for the sense of modernness rather than simply for the last ounce of use” (Slade 2007, p. 58). During the recession that followed, even “planned obsolescence” dictated by government was suggested as a way to reactivate the economy (London 1932). Finally, Brooks Stevens, founding member of the Industrial Designers Society of America, described in the 1950s the concept of “psychological obsolescence” as: “instilling in the buyer the desire to own something a little newer, a little better, a little sooner than is necessary” (Slade 2007, p. 153).

More recently, “consumer confidence,” an economic indicator (emerging property) that translates into spending habits, individuals’ feelings about the state of the economy system in general, and their own financial situations, became a topic central to government policy systems. The idea that consumers would “spend our way out of the recession” has been heralded as the answer to the current crisis, regardless of alarming levels of personal debt in the developed world. Nevertheless, governments all over the world look desperately to the latest retail reports in search of an increase in retail activity demonstrating that “consumer confidence” has returned. According to Cooper (2010), such emphasis on obsolescence and consumption in order to sustain increasing levels of economic growth follows a linear (non-systemic) economic model “which assumes at the outset of any production process that the Earth has an unlimited supply of raw materials and energy and, at the end, an infinite capacity to absorb pollution and waste” (Cooper 2010, p. 12).

Recent initiatives to improve the manufacturing systems of products and the use of natural resources (given that very few companies will openly acknowledge following this linear model) will fail to have a long-term impact if consumption were to continue to increase. Furthermore, new product features could even cancel any “environmental savings” from previous versions of the same product; that is to say, “green shopping,” “green consumerism,” and “sustainable consumerism” still constitute shopping and consumerism. However, our economic system is so dependent on consumerism that a sudden slowdown of production processes could cause high levels of unemployment and other unintended consequences in other areas of the wider social and economic systems. In this context, Cooper (2010) advocates instead a circular “systems thinking” economic model, which “requires that the throughput of materials and energy be minimized by optimising product longevity, reusing or reconditioning products and their components, and recycling – alongside other measures such as energy efficiency” (Cooper 2010, p. 12).

It would be combined with the concept of “slow consumption” (Cooper 2005, 2010). This approach is supported by increasing “product life-span,” which involves improving production processes, creating skilled jobs in repair and maintenance work, consumer satisfaction, and second-hand markets. In sum, Cooper believes that the combination of “longer life-spans” and “slow consumption” (within a “systems thinking” economic model) would provide an antidote to the notion of “obsolescence” and would allow the economy to absorb lower levels of production.
**Systems Thinking and Sustainable Development**

The notion of sustainable development (SD) has taken center stage in the redefinition of the inter-relationships between humans and the environment and between developed and less-developed societies. This notion has become the formal response produced by NGOs, policy makers, and business leaders toward building “the future we want” (UN 2012). On the one hand, it encapsulates the developed world’s anxieties as these emerged from the failed project of development “designed for” the Third World (Banerjee 2003; Escobar 2011) and realizes that the current economic system has produced certain levels of growth, industrialization, consumerism, and inequality that cannot be sustained indefinitely, as discussed above. On the other hand, SD is also informed by evolving discourses regarding notions such as nature, the overexploitation of natural resources, the rights of nonindustrial indigenous populations, the eradication of poverty, and the provision of quality education. The state of play among these genuine concerns has been crystallized in the different UN resolutions, from the 1951 report on *Measures for the Economic Development of Under-Developed Countries*, then the Brundtland Report in 1987, to the creation of 17 Sustainable Development Goals in 2015; one of these goals (SDG4) aims to “ensure inclusive and equitable education and promote lifelong learning opportunities for all.”

Quality education is an issue that needs to be understood and addressed systemically (Banathy 1992; Badrul and Reigeluth 1993; Betts 1992; O’Neil 1995; Por 2008). The need for quality education can be found in less-developed countries, as well as in poor areas in developed societies where poor indigenous and immigrant populations live, or in deprived communities that once enjoyed well-paid manufacturing jobs now outsourced overseas. For example, soft and critical systems thinking could contribute to the required dialogue among multiple stakeholders’ understandings of what constitutes quality and meaningful education (Matengu et al. 2018) and its relationship with training. A distinction exists between policies intended to prepare skilled workers to take up jobs in newer sectors and those to prepare people who, aware of their social and political circumstances, positively and critically engage with other sectors of civil society, government, and businesses, to build the society they want (Freire 1970; Checkland 1981; Ulrich 1983; Fals-Borda 2006). The former does not necessarily preclude the latter, yet the two are not necessary linked. Cultural, religious, and economic circumstances that keep males and females of all ages in/out of education and training or produce unequal access to available opportunities must also be acknowledged.

At the national level, agreement on the desirable qualitative and quantitative outputs of its education system needs careful consideration. These could include years of schooling; the quality of certain acquired skills (literacy, numeracy, negotiation, teamwork); access and future employment prospects; and the effectiveness of training in the creation of small businesses, cooperatives, and other social support systems. The relationship between the education system and other areas of government, and national and international organizations, must also be included for all to take advantage of synergies and economies of scale. Operational research and simulation models could help in understanding the strong and weak points of the system at this level, targeting important national resources to address salient issues, to promote collaboration between government institutions and international organizations, and to allocate resources where the greatest impact can be produced in relation to other Sustainable Development Goals. Systems dynamics, OR (Johnes 2015; Romm 2018), and VSM could be successfully employed at this macro level of analysis (Hart and Paucar-Caceres 2017). However, corruption (Osipian 2017; Duerrenberger and Warning 2018), incompetence, the lack of tight controls, weak judiciary and auditing systems, and the mismanagement of financial resources are problems that could undermine an otherwise fine-tuned and participatory systems design.

At the local level, the analysis would focus on the internal operations of particular schools that
could offer different types of education and vocational training. In this instance, the boundary of this system would be located around a school (or group of schools) as they interact with a catchment area. The elements and processes to be considered would be related to the school’s infrastructure and equipment; class sizes; the number of teachers, their qualifications and experience; the schools’ management structures; enrolment and dropout rates; student progression; success rate in external examinations; curriculum and syllabuses delivered; the demography of the student population; and community, parent, and student relations (Matengu et al. 2018). Soft OR, VSM (Espinosa and Walker 2013), and soft systems thinking could provide insights at this level.

At the individual or family levels, the focus of analysis would center on practical “on the ground” issues that promote, facilitate, and/or prevent students from accessing education and training: family economics, nutrition, and health; cultural and economic reasons for enrolment and dropout rates; as well as access to learning materials, transport, family structures, roles/gender, and the division of labor and childcare at home. Soft systems thinking could capture qualitative aspects of this system in addition to some quantitative information.

From this discussion it is easy to appreciate that those interested in working systemically toward a particular SDG, such as quality education, must deeply liaise and collaborate with experts addressing the other 16 SDGs. As in any form of national government, there are clear synergies between, for example, education, poverty, health, water and sanitation, and infrastructure. There will also be tensions when it comes to where to start and how limited financial and human resources need to be allocated to make a greater and faster impact.

There will be the inevitable impulse by NGOs, consultants, and governments to export successful models and solutions to other countries – without considering the circumstances that made them meaningful and successful in the first place. From a systemic perspective, institutional economists have observed that certain processes (including education systems from advanced economies) are developed in such a way that, over time, it becomes almost impossible to consider alternatives, even if these could provide superior solutions that could be implemented in less-developed communities. Such a phenomenon can be explained by the systems notion of “positive feedback.” Arthur (1994) described some of the conditions necessary for this damaging process to occur: the presence of high setup costs, which could make the implementation of further initiatives even more expensive; the development of specialized knowledge and expertise, which makes governments and agencies reluctant to invest further time and resources in learning, testing, and adapting further models; and finally, the perceived advantages of using methodologies and systems models successfully implemented in more advanced societies. This is to say, a critical systems analysis of the reasons for the failure of sophisticated economic models and systems that have been exported to less-developed communities would be required, if similar results are to be avoided.

**Concluding Remark**

Systems thinking is not new within development issues; NGOs have used systems thinking to address practical problems in the developing world for many years (Bowman et al. 2015).

Systems thinking provides a unique opportunity to learn from and to address social and natural issues. Focusing on elements, clusters (sub-systems), inputs/outputs, interrelationships, and emerging properties will allow those working on any of the SDGs both to appreciate phenomena holistically and to engage with stakeholders. Examples of how systems thinking could be used to address issues at the national, local, and personal levels in relation to SDG4 were provided in the previous section; the same type of analysis could be conducted for the other SDGs. Furthermore, meaningful engagement with current stakeholders (and considering the effects of their recommendations on future generations) will help those working on different SDGs jointly to...
provide feasible and sustainable solutions, without limiting the possibilities of future generations.

However, those working on any of the SDGs need to be aware of issues such as the availability of reliable data; funding; gaps in their understanding; political, ethical, and ideological considerations; and information processing power. These would also contribute to determining the system’s boundaries, its complexity, and its subsequent ability holistically to operationalize the SDGs to improve our present situation. This is to say, systems and systemic thinking are framed within their current social, economic, political, and historical contexts and limitations.

Systems thinking can help us develop just, equal, and sustainable societies, without expanding the developed world’s damaging patterns of industrialization and consumerism to include every region on and each inhabitant of the planet. Systems thinking offers a unique opportunity and a common language through which to communicate and engage with other stakeholders on different SDGs, to go beyond the perceived boundaries of our present situation such that we are able to imagine different futures collectively.

References


Systems Theory: Implementation of SDGs