WEB OF KNOWLEDGE

A LOOK INTO THE PAST, EMBRACING THE FUTURE

Editors
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The Botanic Garden of the University of Coimbra as a Complex Information System

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ABSTRACT: General Theory of Systems, sensu strictu, aims to derive the general definition of "system" as a complex of components in mutual interaction with each other and with the surrounding environment. A theory to be applied to the Botanic Garden of the University of Coimbra, understood as a Complex Information System: a whole with several types of units or information systems, such as a living plant collection, library, museum, archive and herbarium. Júlio Henriques (director between 1873-1918) participated in networks of scientific knowledge and his role is crucial to understand the growth and complexification of the Information System Botanic Garden UC. An example on a new species discovery – Pandanus thomensis Henriq. – illustrates how a systemic and holistic perspective of the information allows a comprehensive knowledge of the information in several supports and locations.

1. INTRODUCTION

Our primary goal is to analyse the Botanic Garden of the University of Coimbra (JBUC) as a Complex Information System. To do so, we applied the General Theory Systems, in particular, highlighting the importance of context. Therefore, we will present examples illustrating how the scientific activity of Júlio Henriques, and the networks he participated in, were crucial to the development and growth of botanical knowledge and plant collections - in the garden, the herbarium, and in amassing a scientific library.

2. GENERAL THEORY OF SYSTEMS (GTS)

In 1997, Piero Mella with the work "Dai Sistemi al pensiero sistemico" updated the systemic theory of Ludwig von Bertalanffy, who in the early 20th century theorised about the "General System Theory". Bertalanffy first presented a theory in 1937, but it was only after the War that he published his first thoughts and works on GST, with application to all kinds of phenomena and systems in general (Bertalanffy 1979; Mella 1997).

In fact, since World War II, several scientific fields, such as logics, mathematics, physics, chemistry, biology, geography and geology, but also, the social sciences, have converted to the new epistemic system (Carreras Gargallo 1984).

2.1. Principles

GTS is a scientific investigation of "sets" and "totalities" which advocates that to understand the whole one needs not only to study its parts or isolated components but also to understand their inter-relations. This means that the whole is greater than the sum of the parts, that the whole is a set of interactive and interdependent parts which, together, form a unit with a definite purpose and function (Bertalanffy 1979; Mella 1997).

Besides, GTS emphasizes the role of context and structural organicity in the genesis of information, providing a complex and comprehensive knowledge of information phenomena (Bertalanffy 1979; Mella 1997).

GTS is thus based on a holistic view and highlights the importance of a comprehensive understanding of phenomena rather than the isolated analysis of its constituents, assessing the inter-relation between all the elements of the system, between these and their parts and with the surrounding environment. (Bertalanffy 1979; Mella 1997).

According to the system thinking, on the one hand, the system becomes a unit in the multiplicity of its components; and on the other hand, the parts lose their individuality in the system, becoming equally essential in the formation of the whole (Silva & Ribeiro 2002).

3. GTS APPLIED TO INFORMATION SCIENCE

3.1. What is information?[1]

The digital environment where "bits and bytes are all equal" broke the "traditional boundaries between various cultural heritage institutions - archives, libraries, and museums" (Timms 2009). The digital technological revolution has raised the discussion about supports and information concepts and promoted the paradigm shift towards a post-custodial, dynamic, informational and scientific view of information.

Silva & Ribeiro define information as a "structured set of codified mental representations (meaningful symbols) socially contextualized and capable of being registered in any material medium (paper, film, magnetic stripe, compact discs, etc.) and thus communicated in an asynchronous and multidirectional way" (Silva & Ribeiro 2002). The focus on the content (information) "eliminates physical distinctions between types of records and thus, presumably, the need for organisational distinctions in the management of the systems within which these records are handled" (Timms 2009).

For Buckland, the concept of information is 'as a thing', 'as knowledge' and 'as process'. The author understands that the first notion of information is the most pertinent for its study in systems, within the scope of Information Science, and we quote: "Information-as-thing: The term "information" is also used for objects, such as data and documents, which are referred to as "information" because they are considered to be informative" (Buckland 1991). In a more recent article, the same author states that if we mean "information-as-thing, we can ask what documents do or, more, correctly, what people do with information-as-thing, with documents, that is to say with data, records, texts, and media of every kind". (Buckland 2012).

3.2. Information System (IS)

An Information System is a unitary complex formed by a plurality of related elements that has information and its management as the central nucleus (Fernandéz Marcial et al. 2015).

In Vickery words: "An information system is an organisation of people, materials and machines that serve to facilitate the transfer of information from one person to another. Its function is social: to aid human communication." (Vickery, 1973). He also considers that "In the broadest sense, a system is a set of interacting components. The components can be entities or processes" and that "Everything outside a system is its environment." (Vickery 1973).

3.3. Complex Information System (CIS)

Piero Mella refers the existence of complex systems which are "systems made up of a very large number of equal (or, at least analogous) elements that interact and which can be studied and interpreted as a unit because they present a unitary, perceptible dynamic, which can have the characteristic of irreversibility and which can give rise to forms of recognizable order or become highly unstable." (Mella 1997).
In 1999 Silva *et al*. adapted the concept to Information Science and used the term "complex heritage system" to define frequent situations in which the Archive, Library and Museum interconnect in a complete unit (Silva et al. 1998: 40).

According to Timms, there are "cultural heritage institutions" such as archives, libraries and museums and also "hybrid" cultural heritage institutions that administer cross-sectoral collections, complex institutions that integrate different types of information systems and generate information in different media (Timms 2009).

The Botanic Garden UC[2] is a 246 years old institution whose mission is research, conservation of biodiversity, education and dissemination of science, with a particular focus on the awareness of the importance of plant diversity, climate change and the sustainable use of resources[3].

From the 18th to the 20th centuries, the Botanic Garden UC was an organic whole, whose management resulted from the interaction and interdependence of the parts (living plant collections, herbarium, museum, library and laboratories). These sections supported the organisation's mission, functions and decision-making, and knowledge production. In the 21st century, due to institutional changes in the UC, the parts of the system are now under different administrative units.

Thus, we will apply the concepts above to understand the Botanic Garden UC as a Complex Information System.

4. THE ROLE OF JULIO HENRIQUES IN THE GROWTH AND COMPLEXIFICATION OF THE COMPLEX INFORMATION SYSTEM BOTANIC GARDEN OF THE UNIVERSITY OF COIMBRA

4.1. Júlio Augusto Henriques (1838-1928)

In 1873 Júlio Henriques (JH), professor of botany, was appointed director of the Botanic Garden of the UC, position that he holds for 45 years.

His action was based on:

- the incentive and increase of the exchange of seeds and plants with other botanic gardens,

[1] About the concept of *information* see also Marques 2017 e 2018.

[2] At present time the Botanic Garden is a Cultural Extension and Training Support Unit of the University of Coimbra.

[3] http://www.uc.pt/en/jardimbotanico

- the development and enrichment of the herbarium and living plant collections, and the museum of botany,
- the acquisition of botany teaching resources and educational materials (3D models, wall charts),
- the vast increase of a specialised library of botany.

4.2. Júlio Henriques and knowledge networks

JH participated in networks of scientific knowledge, built around the Botanic Garden of the UC, which linked scientists that studied flora from the European, American, Australian, and African continents.

At the time, correspondence was crucial for the transmission and sharing of scientific knowledge. Almost 5.000 letters from 1.200 correspondents - national and foreign scientists, academics and non-academics, diplomats and politicians - are a fundamental source of information to understand the growth and complexification of the Information System Botanic Garden UC.

4.3. Júlio Henriques and the Broterian Society (1880-…)

Created by JH in 1880, the Broterian Society[4], named in homage to Avelar Brotero[5], fostered mutual assistance of its members, exchanging among themselves the plants they collected and giving to the Herbarium of the University a certain number of plants. The naturalists of the Herbarium guaranteed the identification of the species and the (re)distribution of the samples collected by the members (Henriques 1883).

At the same time, JH founded the *Bulletin of the Broterian Society* (1st series 1883-1920), a scientific journal that disseminated the researches carried out in the Botanical Garden and Institute of the UC and articles of botany of national and foreign researchers (Silva & Gouveia 2018).

At that period the botanic library only received 5 publications by purchase, all foreign, and 8 acquired by offer. The system of exchange of scientific journals with the *Bulletin* signified a great contribution to the collection meaning 95.9% of the total of the number of entries in the botanical library. And from the 301 periodicals received by exchange with it, 79% were international (Silva & Gouveia 2018).

This is one example of Júlio Henriques' role in the CIS Botanic Garden.

4.4. CIS Botanic Garden growth and complexification: JH's role

The arrival at Coimbra of the *Pandanus thomensis*, an endemic plant of S. Tomé and Príncipe, is one of several examples that illustrates how the scientific activity of Júlio Henriques and the networks he established were fundamental to the development and growth of plant collections in the garden ant the herbarium, the botanic library and of the botanic museum.

In the 19th century, African flora was of great interest for European naturalists. Júlio Henriques always had a great interest in the island of S. Tomé and, in 1885, organised a botanical expedition carried out by the naturalist Adolfo Möller. The plant, first collected by Möller between May and September 1885, and later, until 1887, by Francisco Quintas, a resident in the island, was described and named for the first time by Júlio Henriques. This micro-network Júlio Henriques created and participated in, shows the common interactions in the natural sciences in the 19th century (Gouveia 2014).

This example illustrates how the information on a species – *P. thomensis* Henriq. – is present in several supports. First, the plant material that constitutes the type specimen is held at the Herbarium of the University of Coimbra[6] and, later, the scientific description of this new species (*P. thomensis*, n. sp.) made by Júlio Henriques was published in the *Bulletin of the Broterian Society*[7] and is today at the Library of the Life Sciences Department[8]. Plant products (leaves and fruits) and ethnographical objects (hand-woven mats) made out of *P. thomensis* were part of the Botanic Museum collection, and are today included in the collections of the Science Museum. The relation between JH, Möller and Quintas is recorded in the letters they exchanged, and are housed in the Botanic Archive of the University of Coimbra[9]. Also, of the tropical plants that Júlio Henriques has named, the only one for which a contemporary photograph is known is that of *Pandanus thomensis* Henriq. (Gouveia 2014)[10].

To think and study information as a system implies overcoming conventional divisions or separations (by support, thematic and by institutional category - Archive and Library) (Pinto & Silva 2005).

This is contrary to the idea and practice of a custodial, historicist, patrimonialist and technicist paradigm where different things should go to different spaces, originate specific professional

[4] http://sequoia.bot.uc.pt/sbroteriana/

[5] Félix Avelar Brotero (144-1828) wrote *Flora Lusitânica* (1804) where he identified about 1800 species, many of them unknown until then.

[6] https://www.uc.pt/herbario_digital

[7] Júlio Henriques, (1887). Contribuições para o estudo da Flora d'Africa. Catálogo da Flora da ilha de S. Thomé, *Boletim da Sociedade Broteriana*, vol. 5, 196-232.

[8] https://www.uc.pt/fctuc/dcv/biblos

[9] http://arquivodebotanica.uc.pt/

[10] All of this information can be retrieved in the catalogues of the Botanic Library, Archive and Herbarium of the Life Sciences Department, and Science Museum.

practices and even supposedly independent scientific disciplines (Silva 2015).

As seen in the example above, a systemic and holistic perspective of the information allows a comprehensive knowledge of the information in several supports.

5. CONCLUSIONS

The GTS approach allows a comprehensive knowledge of the origin and circulation of plants and seeds for both the Garden and the Herbarium, the existing scientific publications in the Library of Botany, and the objects in the Botanic Museum (today in the Science Museum of the University of Coimbra).

The networks established by Júlio Henriques show the importance of taking in account the surrounding environment in the systemic view of Information. By looking at surrounding environment and by studying all parts of the system in inter-relation, we have a full understanding of Complex Information System Botanic Garden of the UC.

Today, the digital environment is the setting that can link and bring together the botanical information that is geographically separated but safeguarded by different UC units.

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