v. 3, n. 24, 2023

Scientific Journal of Applied Social and Clinical Science

UNCOVERING THE INVISIBLE FLOWS OF SOCIALIZATION IN KM IN BRAZIL: EDUROAM AS ONE OF THE MAPPING SOURCES

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Abstract: The understanding of the importance of knowledge for the economy is already a consolidated reality. However, the search for understanding how to create an environment that allows and encourages the growth and use of knowledge in organizations is an evolving process. In teaching and research institutions, the search for knowledge and its recognition as the greatest product and contribution to society is undeniable. Given this scenario, this research seeks to investigate where and with what intensity the socialization process described in the SECI model has occurred within Brazilian institutions. For this purpose, records of use of the *eduroam service* over six months were used, processing 1,616,178 records referring to the period from 01/01/2016 to 06/30/2016. Social Network Analysis was used to build representations of these complex networks, with which it was possible to present the flow and relationships generated by social interactions between members of Brazilian and foreign teaching and research institutions within Brazil, highlighting among them USP, IFSC, UFRGS, UFSC and UNICAMP. It was found that only 5.1% of institutions participating in the flows are Brazilian, with the rest of the network made up of foreign institutions with a more intense participation of institutions coming mainly from Portugal, United Kingdom, Germany, Spain, United States, France and Canada.
Keywords: Mobility. Socialization. Social media. *eduroam*. Knowledge.

INTRODUCTION

Man is more than labor. A little over fifty years ago, in economic theory the worker is no longer understood only as a mere manual worker, he is also valued for his intellectual dimension, as his knowledge is an even more valuable factor for organizations. With this perception in the 1950s, the understanding of the existence and with it the importance of the knowledge worker (Drucker, 1957; Viana & Lima, 2010; Schultz, 1961) emerged.

Later, he was also called a "symbolic analyst". Its fundamental relevance for the competitiveness of organizations and knowledge management continued supported by its intellectual capacity (Reich, 1997). In most academic texts, the most used term is coined by Drucker (1957) "knowledge worker".

Given this scenario, Nonaka and Takeuchi (2008) understood this importance and warned of the need to create processes related to knowledge management in order to maximize the use of knowledge as a competitive advantage in organizations.

According to Nonaka and Konno (1998), the so-called "knowledge spiral" described in the SECI model, which we will present in more detail throughout this article, is composed of four phases called: Socialization, Externalization, Combination and Internalization. Among these four phases mentioned, the socialization phase has as one of its main foundations the direct interaction with a minimum of mediation between individuals. Sacerdote (2013) adds that in addition to interactions between individuals, the environment and cooperation in situations and environments promote new constructions.

This article seeks, even if still in an exploratory way, to identify and describe the socialization flows generated by knowledge workers who are members of Brazilian and foreign teaching and research institutions within the Brazilian territory.

These socialization contacts, by their very nature, do not generate records, which makes mapping them even more difficult. There is currently an effort in an attempt to carry out this mapping through the identification of publications with co-authorship between

researchers who may or may not be from the same institution. However, if we use this procedure, we would be mapping the externalization phase according to the SECI model, which, although important, would be closer to the result and not the origin of knowledge creation.

Faced with this difficulty and aiming to contribute to the understanding of how this flow currently presents itself, we will use this mapping indirectly through the use records of a service called *eduroam.*

This service enables secure access to *Wi-Fi networks*[1]. for the international education and research community in more than 60 countries. It has more than 18,000 access points registered around the world, and allows students, researchers and the entire team of institutions participating in the service to obtain internet connectivity within all the campuses *of* institutions that are part of the *eduroam federation,* practically automatically. Therefore, there is no need for any local request in the institution being visited (Eduroam, 2016; Eduroam, 2016a; Terena, 2016).

In Brazil, *eduroam* is operated by the National Education and Research Network (RNP), and currently has 1,244 access points registered and distributed in over 71 participating institutions, including the main universities, Federal Institutes of Education, Science and Technology and Institutes Research (EDUROAM, 2016a; RNP, 2016).

In this study, we are assuming that not all interactions can generate joint publications, thus making their mapping difficult. These interactions generate influences on the birth of new publications. These can make use of knowledge that was obtained, provoked or even contested during the period in which the researcher had contact with a new environment and members of other institutions. This may have influenced both his research and that of others with whom he had contact.

This contact, which still occurs in the form of tacit knowledge between researchers, is directly linked to the socialization phase described in the SECI model and cannot be ignored, as it is part of the spiral of knowledge.

Based on this theoretical perspective, the main question that guided the research was the following: Would it be possible to map the flow of physical interactions between Brazilian teaching and research institutions? Additionally, would it be possible to identify the countries of origin of visitors from foreign institutions and how intensively have they visited Brazilian institutions?

To present and analyze these flows, we will use Social Network Analysis (SAR) as described by Nooy, Mrvar and Batagelj (2005).

THEORETICAL REFERENCE

KNOWLEDGE MANAGEMENT

The true objective of knowledge management, according to Fresneda (2007), does not exactly concern people management, but the facilitation of processes that promote the creation and development of knowledge. Knowledge that, in the view of Devenport and Prusak (1998), is something at the same time fluid, structured and intuitive and can be understood as a process, an asset or a good that can be stored and managed.

The "generation of knowledge", according to these authors, is based on eminently human characteristics as they are built from experience, beliefs and values, considering discernment, norms and the ability to deal with complexity. Therefore, knowledge is something inherent to people.

In addition to these assumptions, Nonaka and Takeuchi (2008) distinguish knowledge, which they understand as "true and justifiable

1. Wi-fi is a wireless network for internet access,equipment that has this technology can connect to each other anywhere at any time (WI-FI ALLIANCE, 2016; WIKIPEDIA, 2016).

belief", into two types (Nonaka & Takeuchi, 1997):

- **Explicit knowledge**: it has formal characteristics, as it is systematic, and can be expressed by numbers and words. Therefore, it is knowledge easily communicated and shared in data, information and even with models;
- **Tacit knowledge:** has personal characteristics, as it is complex, originates from experience and has a contextual dimension (Nonaka & Takeuchi, 1997).

THE SECI MODEL

Dialectical processes in organizations allow for the evolution of knowledge as antagonistic positions arise that provoke new reflections and consequently the emergence of new points of view (Nonaka & Takeuchi, 2008).

The SECI model explains this phenomenon in more detail. The basic patterns of knowledge creation are presented below:

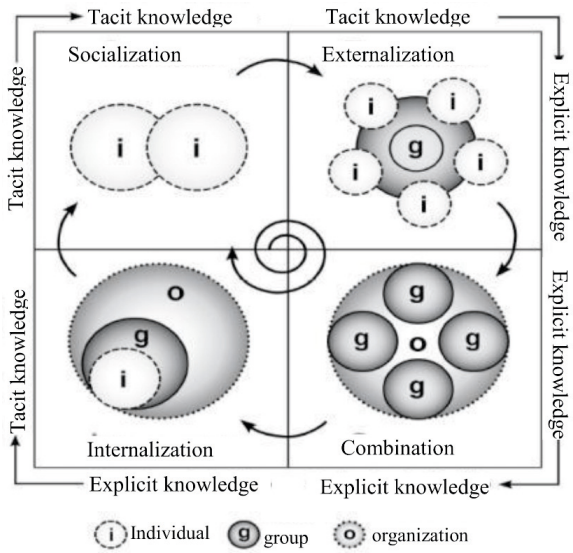

Figure 1 - SECI model of the knowledge spiral

Source Nonaka e Konno (1998, p. 43)

In this model, the meaning of each of these phases corresponds to:

- **Socialization** - Transfer of tacit knowledge to tacit knowledge. Occurs between individuals who can acquire knowledge through observation, imitation, practice, or experience;
- **Externalization** – Transfer of tacit knowledge to explicit knowledge. It occurs between individuals and groups through metaphors, analogies, concepts or models, enabling the creation of new explicit knowledge;
- **Combination** – Transfer of explicit knowledge to explicit knowledge. Occurs in the exchange or combination of knowledge between people via documents, meetings or in the exchange of ideas, promoting the creation of new knowledge that is explicitly available;
- **Internalization** – Transfer of explicit knowledge to tacit knowledge. It is the incorporation of available knowledge, explicitly, in any medium in tacit form for the individual.

SOCIAL NETWORK ANALYSIS

Social Network Analysis (SNA) has contributed a lot to understanding the functioning of social influence, social groups, the spread of diseases, etc. (Newman, 2001) through analyzes that demonstrate emerging and little-known behaviors (Wasserman & Faust, 1999).

Making use of graphs (a set of vertices and a set of lines that interconnect pairs of vertices) it is possible to represent the relationships between the actors within a specific context, where the vertices of the graph represent the social actors of the network and the edges (links that connect the pairs of vertices) represent the social interactions of the network. This representation enables a clearer

analysis of an emerging and little-known behavior (Wasserman & Faust, 1999).

METHODOLOGY

This exploratory study sought to answer the following question "Would it be possible to map the flow of physical interactions between members of Brazilian teaching and research institutions? Additionally, would it be possible to identify the countries of origin of visitors from foreign institutions and how intensely have they interacted with Brazilian institutions? "

For that, the primary data were identified and obtained from the treatment of *log files* [2]generated by *eduroam* which records mobility between members of Brazilian and foreign teaching and research institutions participating in this international network service which, in Brazil, is operated by the National Education and Research Network (RNP).

Based on this data, processing and analysis were carried out based on the definition of the networks, the way they were manipulated, the determination of their structural characteristics and, finally, the visual inspection from their graphs. It is, therefore, an analysis based on the model described by Nooy, Mrvar and Batagelj (2005) and Wasserman and Faust (1999).

Seeking greater clarity and consequent understanding of the phases carried out, we will present the first two phases still in the methodology section and the last two only in the results and discussions section.

DEFINITION OF NETWORKS

The networks used for this study were generated through the processing of *log* files that record the use of secure *WiFi networks* that are part of *eduroam,* focusing on the occurrences of members of an organization that are present in other organizations. In total, 1,616,178 records were processed in the period between 01/01/2016 and 06/30/2016.

In order to preserve the privacy of users, this analysis considered only the fields: institution of origin, institution where eduroam was used *and the* login date. And, in addition to excluding information that could identify the user, records corresponding to the use of *eduroam* at the user's home institution were also excluded since, in these cases, the use would not reflect the situation that corresponds to the focus of this research, or that is, one in which the individual is being exposed to external socialization.

At the end of processing the records and tabulating the data obtained, two files were generated:

- **RedeEduroamCompleta.net** – contains the network summarized by institution. It presents 1,117 vertices that represent the origin and destination institutions of knowledge workers. Of these institutions, 57 are Brazilian and 1,060 are foreign;
- **RedeEduroamPaís.net** – contains the network summarized by country. It features 46 vertices representing different countries, including Brazil.

MANIPULATION OF NETWORKS

After the networks were made available, they were opened using the *gephi software* in version 0.9.1. Then, the tabulated data set, the *DataSets* [3]*, was* enriched, adding the country of origin of each institution accompanied by an attribute with the value one for Brazilian institutions and with the value two for foreign ones.

And, following the theoretical assumptions of Sacerdote, Sampaio, Gonçalves and

2. information regarding actions taken by users of computer systems.

3. It is the set of data normally tabulated by individual (WIKIPÉDIA, 2016a).

Fernandes (2014), some filters were applied. The first of these filters was applied to restrict the analysis to the behavior of national institutions. And a second to observe only the core of the network that has 15-core.

As a result, four networks were defined:

- **R-MUNDIAL** – represents all data from the **RedeEduroamCompleta.net file,** therefore containing Brazilian and foreign institutions;
- **R-BRAZILIAN** – generated from R-MUNDIAL, with the application of the nationality filter equal to one, therefore contemplating only institutions of Brazilian nationality;
- **R-15-core** – generated from R-MUNDIAL, applying the k-core filter, where the parameter of 15 was defined, thus indicating that only the vertices that have the k-core value equal to 15 or greater must be displayed;
- **R-EGO** – represents all data from the **RedeEduroamPaís.net file,** therefore containing the indication of countries that had members of their institutions visiting Brazilian institutions.

RESULTS AND DISCUSSIONS

DETERMINATION OF THE STRUCTURAL CHARACTERISTICS OF THE NETWORKS

For the analysis proposed in this study, the determination of the structural characteristics of the networks was carried out using the *Gephi software*. Through this software, the metrics of degree of centrality, diameter, density, modularity, component connection and clustering coefficient were applied, which can be better visualized in the table below:

Based on this table, it can be stated that the **R-MUNDIAL network** is composed of 1,117 teaching and research institutions, which were mapped within the studied sample. Its density indicates that only 0.3% of possible socialization interactions between these institutions are being carried out without intermediaries, which, in turn, is closely related to the diameter value, which describes the need for intermediation on average of five other institutions. institutions so that knowledge transits between the ends of the network.

The average path length indicates that the transfer of knowledge from one institution to any other in the network requires, on average, the intermediation of 2,293 institutions. Nine communities were identified; however all are part of the same connected component, which demonstrates that all vertices are, directly or indirectly, interconnected.

R-BRASILEIRA network has 57 institutions, generating a density of 16.3% of possible connections between the vertices that make up this network. Its diameter has the value of 4 jumps, which is, therefore, the distance of its greatest extension. In order for the knowledge of an institution to be transferred to any other institution belonging to this network, the intermediation of 2,022 other institutions on average is necessary. Its modularity is 0.023, making it possible to identify 7 communities within the network, although with only two connected components. This detail demonstrates that not all vertices are interconnected.

Almost all vertices are connected to each other, directly or indirectly, forming part of a giant component.

The **R-15-CORE network** has 38 institutions that are interconnected with at least 15 other institutions, generating a density of 36.2% of possible connections between all the vertices that make up this network. Its diameter presents the value of 3 jumps necessary to cross it in its greatest extension. For the knowledge of an institution to be

STRUCTURAL DATA OF THE NETWORKS				
Networks	R-WORLD	R-BRAZILIAN	R-15-CORE	TRENCH
CONTEXT				
Number of Vertices	1,117	57(5.1%)	38(3.4%)	46
Number of Edges	3954	502(13.15%)	516 (13.05%)	45
Graph Type	Directed	Directed	Directed	Directed
NETWORK OVERVIEW				
Middle Grade	7.08	18,246	27.158	1957
Average weighted grade	1,206,919	14,617,982	21,103,974	11,195,978
Network diameter	5	4	3	1
Graph Density	0.003	0.163	0.367	0.022
Modularity	0.474	0.023	-0.028	0
Communities	9	7	4	1
Connected components	1	two	1	1
Strongly Connected Components	1068	8	13	46
OVERVIEW OF VERTICES				
Average *clustering* coefficient	0.449	0.553	0.505	0
OVERVIEW OF EDGES				
Average path length	2,293	2,022	1,473	1

Table 1 - Structural data of the networks

Source: author himself

transferred to any other institution belonging to the network, the intermediation of 1,473 other institutions is necessary. Its modularity is -0.062 and it is possible to identify 4 communities within the network, which are within the same giant connected component. This demonstrates that all vertices are, directly or indirectly, interconnected.

R-EGO network is made up of 46 countries, which directly influences its density, with 2.2% of the possible connections between the vertices that make up this network. Its diameter presents a value of only 1 hop to cross the entire network in its greatest extension. Its characteristics do not allow an analysis of the necessary amount of knowledge intermediation to be transferred within the network, as the analysis in question is not considering the performance of members of Brazilian institutions in foreign institutions.

VISUAL INSPECTION OF NETWORKS

For the visual inspection of the networks, we performed the presentation using graphs, which are graphic representations of the networks with their actors and characteristics (Nooy, Mrvar & Batagelj, 2005), which were organized using the *Funchterman distribution algorithm Reingold* who presented greater clarity in the visualization of these.

The graphs presented below represent respectively: the network with all institutions (Brazilian or foreign) that had socializations with Brazilian institutions; the network containing only the socializations carried out between Brazilian institutions; the network with institutions that have 15-core; and the ego network of Brazilian institutions.

To differentiate the vertices, all graphs have green pigments, to identify Brazilian institutions; and pink, to identify foreign institutions.

Figure 2, below, shows the *graph* of the previously mentioned R-MUNDIAL network. It contains points that represent 1,117 institutions, which are interconnected by edges that represent the mobility carried out by the members of the institutions (Brazilian or foreign). An edge is generated every time a member user of an institution uses *eduroam* in another institution different from his own.

For each edge, the number of recurrences was calculated, that is, the number of times that the relationship between specific vertices was repeated, storing what we call weight in each edge respectively. The weight of each edge will allow us to differentiate between weak relationships (with few occurrences of relationships between institutions) and strong ones (with many occurrences).

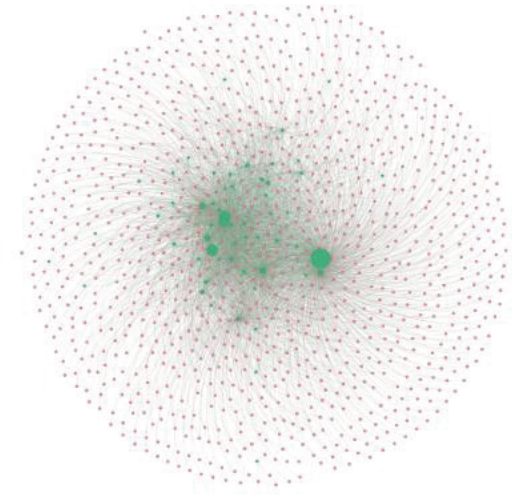

Figure 2 - Network of Brazilian and foreign institutions

Source: own self

Figure 2 contains the representation of all the institutions involved in our study, thus providing an overview of the socialization process of the institutions that carried out interactions within Brazil.

The size of each vertex was defined based on its weighted entry degree. This way, institutions that received more visitors have larger vertices: the larger the vertex, the greater the number of visitors. And, as mentioned earlier, the green color indicates that the institution is Brazilian while the pink color represents foreign institutions.

Unfortunately, because this network contains many vertices, the presentation of the labels of each one of them has become impracticable. However, data analysis showed that national institutions were more concentrated in the center of the graph, with few national institutions close to the edges. However, when this happened, the weighted degree of entry was low, indicating that they received few visits and consequently had low participation in the socialization flow from the perspective of receiving visitors.

Figure 3 below presents a better perspective for demonstrating socialization flows in Brazilian institutions. This figure was obtained by applying a filter to suppress foreign institutions, leaving only Brazilian institutions.

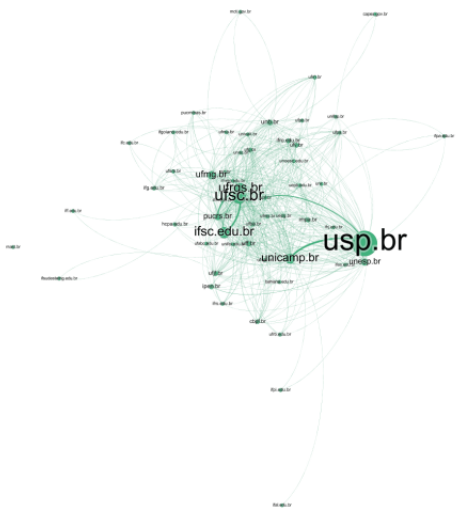

Figure 3 - Network of Brazilian institutions

Source: author himself

In figure 3, the position of the vertices remains the same as in figure 2, adding, however, the identification of the vertices. With this, one can observe the prominent

position of ``Universidade de São Paulo`` (USP) followed by ``Universidade Federal de Santa Catarina``(UFSC), ``Universidade Federal do Rio Grande do Sul`` (UFRGS), Federal Institute of Santa Catarina (IFSC) and State of Campinas (UNICAMP), these being the five national institutions with the highest flow of members.

noteworthy is the presence of some edges with greater width, thus demonstrating the greater intensity in the relationship between some of these institutions, such as, for example, the relationship between USP and UNICAMP.

Figure 4, below, presents the graphical representation of the network core analysis showing only the vertices that are 15-core or higher. Based on this, it is possible to state that, of the 38 institutions that are part of this network, 27 are Brazilian and 11 are foreign.

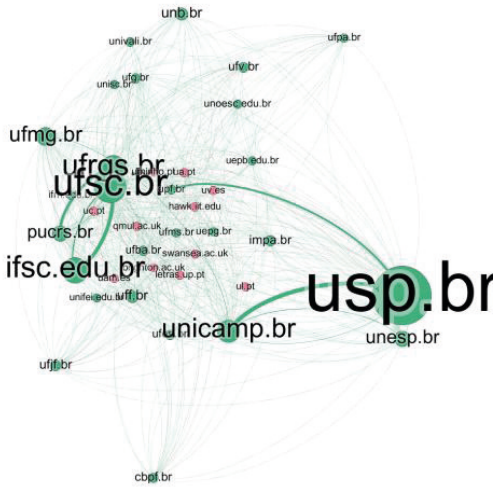

Figure 4 – Institutions' 15-core network

Source: author himself

As can be seen in this figure (4), the institutions that are part of its core have a large number of connections. However, their destinations are not uniform and there is still a very large difference in the intensity of the five largest vertices in relation to the others.

This graph highlights the presence of the following Brazilian institutions: ``Universidade de São Paulo`` (USP), Federal Institute of Education, Science and Technology of Santa Catarina (IFSC), ``Universidade Federal do Rio Grande do Sul (UFRGS), ``Universidade Federal de Santa Catarina`` (UFSC) and ``Universidade Estadual de Campinas``(UNICAMP).

In addition to these, the following foreign institutions also stand out: University of Brighton (grighton.ac.uk), Queen Mary University of London (qmaul.ac.uk), Swansea University Prifysgol Abertawe (swansea.ac.uk), Illinois Institute of Technology (iit.edu), University of Porto (up.pt), University of Aveiro (ua.pt), University of Coimbra (uc.pt), University of Lisbon (ul.pt), University of Minho (uminho.pt), ``Universidad Autonoma de Madrid`` (uam.es) and Universitat do Valencia (uv.es).

Finally, figure 5 allows, like figure 2, to have a broad view of the current socialization situation. Quantitatively, however, there is not much to be gained from its visual inspection.

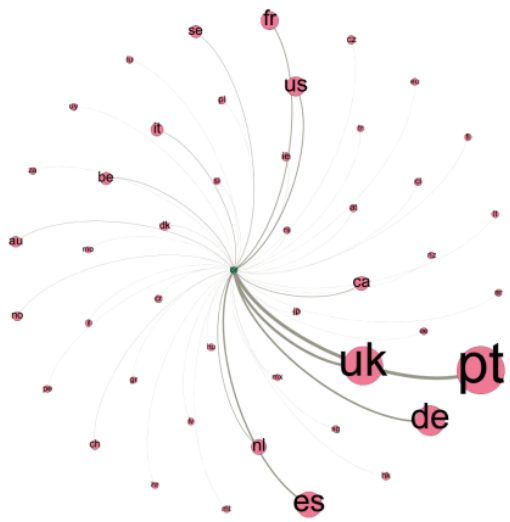

Figure 5 - Ego network of Brazilian institutions

Source: author himself

Unlike the other *graphs* presented here, the size of each vertex used the weighted degree of output, thus providing a highlighted

visualization of the countries that sent the most knowledge workers to Brazil, where they stand out: Portugal, United Kingdom, Germany, Spain, United States, France and Canada.

FINAL CONSIDERATIONS

Throughout this study, the use of data from *eduroam usage records* proved to be a viable source in providing information on the mobility of knowledge workers linked to teaching and research institutions, enabling the elaboration, and subsequent analysis, of data files. networks that reveal the relationships between institutions using this international network service.

The use of Social Network Analysis (SAR) as a method for mapping socialization flows, within the perspective presented in the SECI model, also proved to be viable, presenting, as we have seen, the representation of interactions between national and foreign institutions based on their registration in Brazilian territory.

In the analyses, based on the flows obtained through the ARS, the predominant participation of institutions located in the south and southeast regions of Brazil was highlighted, thus indicating a greater intensity in the socialization of knowledge in this region. Some of the institutions in this region (such as USP, IFSC, UFRGS, UFSC and UNICAMP) are even making intensive use of the knowledge socialization process within the studied perspective. In other regions, the low intensity of interaction suggests the existence of opportunities to maximize the development of this type of interaction.

Additionally, when discussing the results in Brazil's ego network, we identified the predominant presence of European and North American countries in addition to a low interaction with countries from the African and Asian continent, which also suggests an opportunity to improve the socialization of knowledge with these regions.

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