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SAFETY CULTURE AND NETWORKS OF INFLUENCE

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ABSTRACT

This paper analyzes the social networks that influence the formation and maintenance of the safety culture within the Institute of Energy and Nuclear Research (IPEN-CNEN/SP). From the mapping and analysis of social networks, actors with a significant degree of influence were identified. Later using a questionnaire, the beliefs of the population sample were mapped. Thus, the importance of key actors in the network analysis could be confirmed statistically. Therefore, based on the mentioned methods we could demonstrate our hypothesis, that there are some social networks that are important in the formation of safety culture, as well as the fact that the influence of some distinguished actors plays an essential role in this amalgam.

1. INTRODUCTION

Safety culture is a more systemic way to examine the reasons why accidents occur. It represents the most current approach to address this issue. Today, it has become much more difficult to understand why accidents occur, since the relevant causes have become more diffuse and multifaceted nature. The main reasons contributing to this situation are: (a) the growing complexity of modern facilities, many with multiple purposes, inputs and outputs, diverse process chains, many specialized teams and distributed coordination mechanisms, (b) competitive pressure for high throughput and performance, and (c) the complexity of management.

Considering this context and the occurrence of some accidents, such as the Challenger explosion on January 86 and the Chernobyl reactor accident in April 86, there was a strong interest in the study of safety culture, a term coined the International Atomic Energy Agency (IAEA). In this case, the emphasis is more organic in an assessment of why accidents happen,

where management and organizational causes, rooted in culture, have become focus of the study.

This study attempts to understand the dynamics of how a set of attitudes and characteristics of safety culture "emerge" in an organization and who are the main actors in this formation. For this, the social networks that influence the behavior of individuals and groups in relation to safety, were mapped and analyzed.

Using a survey technique 'snowball', the most representative sample of the population of the IPEN workers, who are directly interested or involved with nuclear safety, has been mapped and surveyed. Seven different social networks were included. In addition, a survey of the representative beliefs of the safety culture was performed. The results of both methods were analyzed separately and then correlated so that we could demonstrate the hypothesis.

2. SAFETY CULTURE, MEMETICS AND SOCIAL NETWORKS

Over the past 30 years, many scientists who study safety have directed their attention to the organizational environment, in particular the concept of "safety culture" in order to make the organization more resilient to unwanted occurrences.

Wiegmann et al.[1] have found that the theories about the processes related to accidents have evolved in several stages over time, as described below:

1 - The first stage is often referred to as the technical period, during which developments in new mechanical systems were rapid and most accidents were caused by mechanical malfunctions, particularly in the design, construction, and reliability of equipment.

2 - The second stage is known as the period of human error, where faults of the human operator, rather than mechanical malfunctions, were seen as the source of the system breakdown.

3 - The third stage is referred to as the sociotechnical period. This view of human error considers the interaction of human and technical factors when exploring the causes of errors and accidents

4 - Finally, recent years have witnessed the development of a fourth stage, which is often called the "organizational culture" period. This approach recognizes that operators are not performing their duties or interacting with technology in isolation, but rather they are performing as a coordinated team of organizational personnel, which is embedded within a particular culture.

A classical definition of culture was established by the British anthropologist Edward B. Taylor - "Culture ... a complex system which includes knowledge, beliefs, art, morals, laws, customs and any other habits acquired by man as a member of society." Taylor[2]. Dawkins[3] has conceptualize it indirectly by asserting that most of the usual (concepts and practices) of humans can be summarized in the word culture.
Schein points out that the word culture used by the layman, has a connotation of sophistication, and that anthropologists refer to culture as customs and rituals that societies have developed over time. It also highlights that in recent decades the term culture has been used by researchers and managers to refer to shared values and beliefs of an organization. The same author produced one of the most widely adopted definitions of the term:

"a pattern of basic assumptions – invented, discovered, or developed by a given group as it learns to cope with its problems of external adaptation and internal integration; that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems". Schein[4].

2.1. Organizational Culture

Haukelid[5] noted that the 1980s saw the growth of an intense interest in linking organizational culture with management. Among the many publications on the subject became more popular "In Search of Excellence" (Peters and Waterman[6]) and "Corporate Cultures" (Deal and Kennedy[7]). These books describe the qualities of successful companies and how they work. The message of these books is that corporations with a strong culture are successful, particularly if the management style to emphasize the basic values and common goals.

In the view of Hofstede[8], organizational culture is the top management of the business. Schein[4] uses the term organizational culture as: - "*... observed behavioral regularities when people interact (language, customs and traditions, rituals), group norms, espoused values, formal philosophy, rules of the game , climate, embedded skills, habits of thought / metaphors, mental models and paradigms language, shared meanings and / or integration of symbols*" Reason[9] defines organizational culture as: - "*... shared values (which are important) and beliefs (how things work) that interact with the organization's structure and control systems to produce behavioral norms (the way how we do things around here)*". Glendon and Stanton[10] revealed that organizational culture does not belong to any group, but is created by all members of the organization.

2.2. Safety Culture

There is no consensus about the concept of safety culture, Antonsen[11]. Just as the concept of culture has become known for its variety of definitions and concepts, the concept safety culture was also defined and used in different ways. According to Antonsen[11] most cited the concept of safety culture seems to be the definition of the Advisory Committee on the Safety of Nuclear Installations, ACSNI[12].

The IAEA proposes the following understanding: - "The culture of any organization in the international nuclear industry is centered on safety. This reflects human awareness of the significant destructive capability of nuclear power when control is lost, and the recognition that strict attention to safety is essential if the benefits of this form of power are to be obtained. For a nuclear organization, safety culture is the dominant aspect of the organizational culture."(TECDOC-1329,[13]).

The IAEA refers to points that are the foundation for operational safety (TECDOC-1329, [13]): 1. The existence of strategic plans and action plans with integrated safety to all aspects of the organization's activities; 2. The presence and quality of systems to control organization's risks; 3. The presence and quality of management information systems for organization's safety; 4. The extent to which each employee receives high quality training in workplace integration and safety. These elements, individually or together do not constitute a

safety culture, although they are an important part of it. These features can be seen, so they are at the outer level (artifacts) of the three-level model for organizational culture proposed by Schein[4].

2.3. Memetic replication and Culture

This term was coined by scientist and professor at the University of Oxford, Richard Dawkins when he has stated: *"... cultural transmission is analogous to genetic transmission in that, although basically conservative, it can give rise to a form of evolution* " Dawkins[14].

Dawkins meme was conceptualized as follows: "...'meme' can be defined as an entity that is capable of being transmitted from one mind to another ... Memes propagate themselves in the set of memes leaping from mind to mind through a process that, in its broadest sense, can be called imitation. Memes can be music, fashion, rituals, and ways of doing things, values or behavior patterns. "Dawkins[14].

2.4. Social network analysis

For Emirbayer and Goodwin[15] social networks are collections of links that connect the various actors and that may be of different types, present different content and different structural properties. Wasserman and Faust[16] define social networks as a set of two elements: actors (people, institutions or groups) and their connections.

For Wasserman and Faust[16], social network analysis is based on the concept that the relations between units are important. Therefore, the relations defined by connections between parts are fundamental components of the relational approach. Two concepts should be emphasized : i) the actors and their actions are seen as interdependent, ii) relational ties (linkages) between actors are channels for transfer or flow of resources (tangible or intangible).

3. RESEARCH METHODOLOGY

Initially we have looked for literature with a focus on the nuclear area and which presented safety culture (climate) questionnaires duly tested and evaluated by statistical methods applied in more than one instance of time. However, although we found several studies and evaluation questionnaires, there was no statistical validation of their structural and measurement models. This fact led us to consider research work from other areas equally complex. Two examples have caught our attention: the off-shore oil platforms (Tharaldsen, [17] and companies in the field of construction (Pousette[18]).

These studies were conclusive in their approaches using multivariate statistics and psychometrics they proved the validity of their models. In addition, longitudinal and multi-group studies have been conducted that provided more evidence of robustness and in the predictive capacity of certain variables (Cheyne et al[19]) and Pousette[18]. We have confronted the dimensions of these studies with the characteristics and attitudes of safety culture proposed by the International Atomic Energy Agency (SCART[20]), to identify what is substantially "identical." In addition, we made the cross-reference between the dimensions of the following studies: (a) Pousette[18], (b) HSE[21], (c) Obadia [22] and (d) SCART[20].

From the common points of the studies mentioned above, four remarkable features were selected. For each one a set of questions were prepared to allow us to map their social networks of influence. The chosen features were: (a) **vision of safety**, (b) **openness and communication**, (c) **collaboration and teamwork**, (d) **organizational learning**. Then, from there, with three draws up questionnaires were the following purposes:

i) identification of the population to be surveyed;
ii) mapping of the influence networks;
III) mapping of beliefs about safety.

Within IPEN our focus was directed only to people whose a relevant part of his/her working tasks take place on the premises of: reactors, fuel fabrication, accelerators, radiopharmaceuticals facilities, radiation protection or radioactive waste. The process of survey / mapping was completed in three steps:

1. *Selecting the "seed group" based on a list supplied by managers or responsible for the areas listed above that, in their view, represent important players in shaping the values and basic assumptions regarding safety in the context where they work.*
2. *The mapping of networks and delimitation of the sample followed the technique of "snowball". To the seed group the network questionnaire, which meant for each one to answer questions indicating whose persons influence him/her on concepts and behaviors related to the four remarkable features described in (a) to (d) above. The new names arise spontaneously were also included in the survey, increasing the sample basis. We made three rounds of this process we decided to stop because the proportion of new actors has become significantly smaller.*
3. *The beliefs questionnaire was sent to the actors who had three or more indications in the survey "snowball." This questionnaire used a 5-point interval scale with neutral element.*

Table 1 contains a summary of the field research in IPEN, showing the stages with their results.

Table 1: Summary of the survey process

Cycle	Step	Target Audience	Tool	New Indication	Final Amount
1	See group selection	Managers	Invitation letter	10	10
2	Initial Survey	Indicated by managers	Questionnaire via internet	29	39
3	Survey Snowball 1	Indicated in the Initial Survey	Questionnaire	23	62
4	Survey Snowball 2	Indicated in the survey snowball 1	Questionnaire	13	75
5	Survey Snowball 3	Indicated in the survey snowball 2	Questionnaire	9	84
6	Beliefs questionnaire	The most suitable	Questionnaire	-39	45
7	At this stage, from 84 appointed, 45 completed the beliefs questionnaire				

3.1. The way to analyze the networks

Each network was evaluated using global metrics (within the network) and individual metrics (part of the actors), as follows.

> **Global metrics**: • Average distance; • Density; • Fragmentation and • Number of boundary spanners in the reduced network.
>
> **Individual metrics** to identify the most influential actors in each network: • Total Degree; • Click Count; • Centrality Hub and • Betweenness Centrality.

3.2. The cultural vector

There is no intention to propose that 10 variables are sufficient to fully characterize the safety culture of an organization. On the other hand these variables were chosen based on the most present indicators in many models of evaluation of safety culture collected in the literature. Thus these 10 indicators, in principle, can give an adequate characterization of the belief position of each individual in relation to the safety culture at IPEN-CNEN-SP.

Let us consider a space with ten dimensions, whose coordinates are, respectively, each of the indicators. In this cultural space vector of each person is represented by a point, located by ten coordinates. This distribution (45) points represents the "safety culture" of the people surveyed (45 people).

Our argument is that if: (a) influence networks have been well mapped, (b) they are significant for the formation of culture, and (c) the indicators to identify the most relevant actors were well chosen, then, gathering a small set of most prominent actors should yield a privileged sample should to represent the population mean. This will be verified later.

Based on the cultural vector of each of the 45 employees surveyed, the coordinates of the centroid of the distribution were calculate and then, using the Euclidean distance, the distance of each vector to the centroid was calculated.

3.3. Structure and meaning of the studied networks

The study was aimed to identify what are the relationships that most influence the behavior of safety in the IPEN-CNEN-SP. From the study we highlight the following networks: Perspective View of Safety (VS); Openness and Communication Network (OC); Teamwork Network (TW); Organizational Learning Network (OL); and Aggregate Network – composed by a binary union of the four networks (VS, AC, TE and AO).

Before commenting the analysis of the network, it is necessary to discuss the meaning of the relationships depicted in the networks.

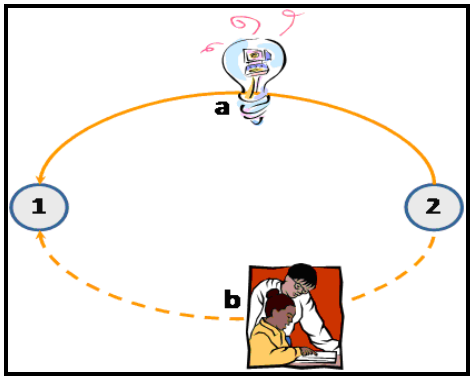

Figure 1: Scheme of the flow of influence

3.3.1. Meaning of links: Perspective View of Safety (VS)

Consider Figure 1, the directed arc (edge) a, from node 2 to 1, indicates that actor considers actor 1 as a model for him in regard to actions, attitudes and opinions concerning safety. Edge b then indicates that actor 1 also resources to 1 whenever he/she has a doubt concerning safety.

3.3.2. Meaning of links: Openness and Communication (OC)

Here link ***a*** express that 2 recognizes 1 for his/her great capacity for direct communication (ease of expression, clarity in the exposition of ideas, etc.). Directed arc ***b*** indicates that 1 is recognized by 2 for his/her ability of indirect communication (an important person in creating or improving the systematic and channels of communication).

3.3.3. Meaning of links: Network Teamwork (TW)

The relationship a identifies that actor 2 believes that the actor 1 is featured in collaboration and teamwork. The second issue explores a relationship of team composition and edge ***b*** indicates that actor 2 have participated together with actor 1. It is important to note that for the relationship ***a*** happen, not necessarily the relationship ***b*** must exist.

4. NETWORK RESULTS

4.1. Aggregate Network

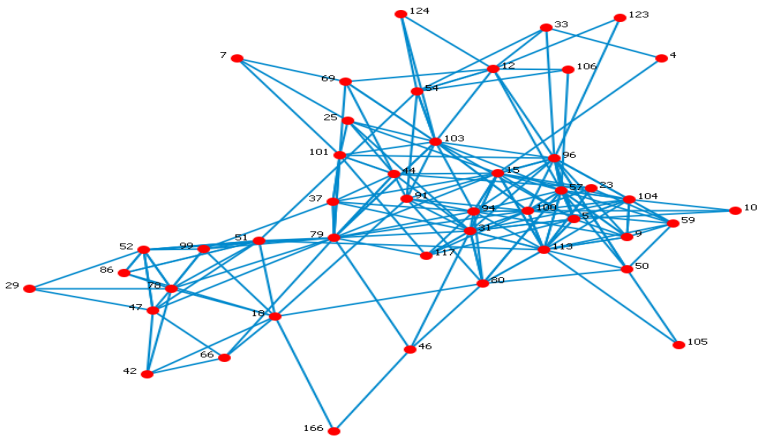

Figure 2 – Aggregate influence network of the safety culture

Figure 2 and table 2 give the overall insight on configuration of the global network of influences.

Table 2: - Features and Indicators of aggregate network

Indicators	Aggregate network
	VS+OC+TW+OL
Node count	45
Link Count	211
Component Count	1
Pending Count	0
Fragmentation	0
Density	0,11
Reciprocity	25%
Average Distance	2,45

4.2. Basis for analysis of the most influential players in the network influences

Table 3 refers to the selection of the 5 most influential actors in a subset of indicators from the 3 first networks. OL network was too fragmented and because of this was left out of the analysis. Data was based on the report "Key Entities: Who" extracted from the ORA software. The background considerations for chosen metrics are described in subsection "a way of analyzing networks."

Table 3: Ranking of Importance (soft power) of the social network by indicator

Index	Perspective View of Safety					Openness and Communication					Teamwork				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Total Degree Centrality	31	57	113	94	96	79	113	31	100	103	113	5	9	15	104
Clique Count	31	113	57	94	100	31	57	79	113	5	15	104	113	9	78
Hub Centrality	57	166	31	94	113	42	52	113	99	100	113	5	59	57	9
Betweenness Centrality	79	96	57	31	113	103	100	91	94	96	113	94	15	37	57

4.2.1. Most Influential Employees

From the results provided by the ORA software form the Table 4 to help us understand who the most influential players. Let us adopt the following criteria: (a) include the best ranked actors whose indicator sums reaches or exceeds 50% and (b) cut at a point where there is a significant difference between the last included and the first excluded. With these five criteria are the most important stakeholders, namely employees of identification code 113, 57, 31, 94 and 100.

Table 4: Ranking of the most influential employees

Ranking Aggregate Network				
Pos.	Employee Id	Occurrences count	Occurrences (%)	Total (%)
1	**113**	**11**	**18,33%**	**18,33%**
2	**57**	**7**	**11,67%**	**30,00%**
3	**31**	**6**	**10,00%**	**40,00%**
4	**94**	**5**	**8,33%**	**48,33%**
5	**100**	**4**	**6,67%**	**55,00%**
6	5	3	5,00%	60,00%
7	9	3	5,00%	65,00%
8	15	3	5,00%	70,00%
9	79	3	5,00%	75,00%
10	96	3	5,00%	80,00%
11	103	2	3,33%	83,33%

4.3. Examining the results

Table 5 presents a summary of the main indicators of all the networks so that, with this vision of the whole, it is easier to do a comprehensive analysis and comparison between the networks. The network will ***VS*** and most importantly the nature of the relations it involves. Furthermore it is the most robust of the individual networks show their contents as density, fragmentation, reciprocity and middle distance. The following are the networks ***OC*** and ***TW*** rates are close, but with a slight advantage for the latter. On the other hand the nature of the relationship (the ability to direct communication) ***OC*** network is a little more relevant than the ***TW*** network.

Table 5: Key indicators of all networks

Index	Aggregate Network	VS	OC	TW	OL
	(VS+OC+TW+OL)				
Nodes count	45	45	45	45	45
Link count	211 *	120	84	94	49
Total Components	1	3 (2 isolated)	3 (2 isolated)	3 (2 isolated)	9 (6 isolated)
Pending count	0	8	8	8	10
Fragmentation	0	0,0879	0,0879	0,0879	0,5384
Density	0,11	0,0606	0,0449	0,0475	0,0283
Reciprocity	25%	12%	8%	14%	5%
Average Distance	2,45	2,8276	3,7196	3,0884	1,8433 **
Boundary spanners(qtd)	0	8	8	8	10
the most influential actors	113	31	100	113	irrelevant
	57	57	113	9	Irrelevant
	31	113	31	15	Irrelevant
	94	94	79		…
	100		103		

The discussion about the importance of the connections represented in each network is qualitative and should be qualified and contextualized according to the purpose of analysis. The noblest use of the present study is to assist so you can most effectively improve the safety culture of the organization examined. In this context, consider that indicative of the influence relationships between people are the most important.
The following outline some arguments to describe this importance:

1. *If you think a particular person as a model of vision of safety in terms of actions, attitudes and opinions, then that person has a great potential to influence him in matters of this nature;*
2. *If in addition, that person is the one you are looking for when they have questions related to safety, then in addition it has many potential opportunities to influence him;*
3. *If this person has great capacity / ease of direct communication, then that person shall be effective on the opportunities that you have to influence;*
4. *If you consider a person as skilled in creating (or improving) the systematic and communication channels, then it may be useful to organize this, but is not this quality it will have any influence on you in a matter of safety;*
5. *If you consider that a person is very skilled and synergetic team work, because it animates the group is pro-actively manage conflicts and everyone can give their best, this does not mean that this person will influence their opinions. On the other hand it will facilitate the achievement of consensus in the group and if people have the opportunity to influence this possibility will be amplified. In group activity programs to strengthen the safety culture is important that such persons are present in all groups;*
6. *If in addition to expressing the opinion of the previous item about a person, you said that last year took part in some group work with it, this reinforces the credibility of the former opinion, because this is a quality that people can improve or reverse the time.*

Note that the arguments 1 and 2 refer to the relations b of the VS network, 3 and 4 refer to the relations b of the OC network, and the 5 and 6 refer to the relations b of the TW network. From the foregoing the following assumptions are very plausible:

- In any program aimed at improving safety culture in which people are the most effective multipliers are those of greatest centrality in a weighted network that included VS relations a and b and compared to OC. Also are these people whose cultural vector would have greater explanatory power of the distribution of vectors of the population. Alternatively we would use the most central actors of the network VS. A positive event was the fact that most central of all actors VS network, and realized that three of the five OC network appear to be the most important aggregate network.
- Also on the program's initiatives to improve the safety culture involving development/improvement of systems and processes of communication, people have more centrality in the network detected involving the relationship of the OC network with a greater weighting to the relationship b must be involved. In the form in which networks were compiled that you can not be done, but here are worth the same observations made in the previous item;

- Programs to improve the safety culture typically involve various group work and in this case the most important actors in the TE network, with the caveats above must be distributed in groups.

5. CHARACTERIZATION ANALYSIS OF SAFETY CULTURE

Table 6 shows all 45 players of cultural vectors that satisfy the search criteria. It contains 12 columns: the first contains the employee ID that was assigned when he began participating in the survey process; the following ten are the coordinates of the vector, the score chosen by the respondent to each of the 10 questions in a 5-point interval scale, with neutral element (from -2 to +2). The last column is an aggregate score representing the respondent.

The latter index is calculated as a direct sum of the responses, since all answers reflected perceptions / opinions either negative or positive about the assertions that were made. Thus this index (with variations from -20 to +20) captures how positive or negative is the global, the perception of respondents regarding to emblematic conditions (reflexive variables) of the safety culture.

Last line shows the averages of each coordinate, which are the coordinates of the centroid of this distribution of the cultural vectors in this hyper-space of 10 dimensions. The mean score gives an idea that the population has a fairly positive overall perception of safety culture, although with plenty of room to improve. This analysis could be particularized for the units that the respondents are allocated, since the questions referred to the working conditions of each one. This would reduce the statistical power of each separate analysis, but could give a good indication where the culture is more fragile.

Table 6: Cultural vectors characterizing the respondents' beliefs

ID	coord1	coord2	coord3	coord4	coord5	coord6	coord7	coord8	coord9	coord10	Escore
10	-2	-2	-1	-2	-1	1	-1	-1	-1	-1	-11
103	-1	-1	-2	-1	-1	-1	-2	-1	0	1	-9
47	-1	0	0	-2	1	-1	-1	-2	0	-1	-7
18	1	1	-1	-2	-1	-1	-2	-2	0	1	-6
42	1	1	1	-1	1	-2	-2	-1	-2	-2	-6
51	-1	-1	0	0	0	0	0	0	-2	-1	-5
69	-1	-2	-1	-1	-1	-1	1	1	1	1	-3
94	-1	-1	-1	-1	0	-1	1	1	1	-1	-3
52	1	-1	1	1	1	-1	1	-1	-1	-1	0
29	1	2	1	-1	-1	-1	-1	-1	1	1	1
46	1	1	-1	-1	0	0	0	1	-1	1	1
23	1	2	1	-1	0	-1	-1	-1	1	1	2
9	-2	2	2	-2	1	2	2	-2	1	1	5
166	0	1	0	1	0	0	1	1	1	1	6
66	-1	0	2	-1	1	1	1	1	1	1	6
37	1	2	1	1	1	0	0	1	1	0	8
4	1	1	1	2	2	2	0	1	-1	0	9
100	1	1	1	1	1	1	1	1	1	0	9
7	2	2	1	1	1	1	-2	0	1	2	9
105	1	1	0	2	2	1	0	0	1	2	10
124	1	1	2	1	2	1	1	1	-1	1	10
15	1	1	-1	1	1	1	2	2	1	2	11
50	2	2	1	2	-1	2	2	-1	2	0	11
57	1	1	1	2	1	1	2	1	1	0	11
123	1	1	1	1	1	1	1	1	1	2	11
5	1	2	-1	1	1	2	2	1	1	2	12
33	-1	2	2	1	1	1	2	1	1	2	12
12	1	2	1	1	2	1	2	0	1	2	13
78	1	2	2	1	2	1	1	2	1	0	13
104	1	2	1	1	1	2	2	1	1	1	13
113	1	2	1	1	1	1	1	2	2	1	13
91	1	1	1	1	2	1	2	1	2	2	14
101	1	2	1	1	1	2	1	2	1	2	14
31	2	2	1	1	2	1	2	2	1	1	15
79	1	2	2	2	2	1	2	1	1	1	15
25	2	2	2	2	2	2	1	-1	2	2	16
80	1	2	2	2	1	2	2	1	1	2	16
54	2	2	2	1	2	2	1	1	2	2	17
96	2	1	1	2	2	2	2	2	2	1	17
44	2	1	1	2	2	2	2	2	2	2	18
59	2	2	2	1	2	2	2	1	2	2	18
106	1	2	2	2	2	2	1	2	2	2	18
99	2	2	2	2	2	1	2	1	2	2	18
86	2	2	2	2	2	2	2	2	1	2	19
117	1	2	2	2	2	2	2	2	2	2	19
Média	0,76	1,16	0,84	0,64	1,00	0,82	0,84	0,58	0,82	0,98	8,44

Figure 3 shows the scores of respondents in ascending order. It may be noted that there is a large majority with positive perception. Looking at Table 6, where the most central actors of the aggregate network are identified, in the ID column, with the numbers 94, 100, 57, 113 and 31 it may be noted that four of them are on the positive side, above average, but a one is the negative side.

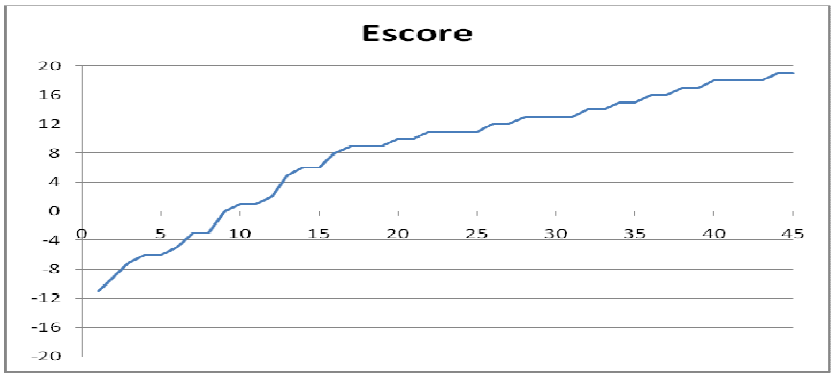

Figure 3: Scores of respondents relating to the cultural vector

5.1. Characterization of Cross-Analysis of Safety Culture With the networks of influence

There is a conjecture, mentioned earlier, that if the most central actors do influence the others then be some indication of this fact should be noticeable by comparing the cultural vectors of the influencers and of the influenced ones. There are several ways to test this conjecture, which if proved would give an extraordinary validation of the proposed use of the results and methodology described here. These applications would greatly help the design of more effective programs for implementation or improvement of safety culture.

Two tests will be made as follows:

a) The first is to compare the mean score of the population with the mean score of five most central actors of the aggregate network.

- The average scores of the most central quintet is 9.00 and the average scores of the "population" is 8.44;
- Then apply a statistical test to verify if the difference between these two numbers is not statistically significant for the distribution under consideration

b) The second is more sophisticated and considers the distribution of 45 vectors in the space of ten dimensions:

- The coordinates of the centroid of the distribution (from now on **Centroid**), are used to translate all coordinate axes in such a way as all vectors become expressed in the centroid system and their Euclidean distances to the **Centroid** are easily calculated.
- If the most central (actors) quintuplet (from now on key quintuplet) is really influential it is expected that the distance from its centroid to the **Centroid** should be approximately in the (center) mean of the distribution of distances of all the quintuplets that can be generated by a bootstraping process from the 45 vectors of the original ("population"). This was done and 1,221,759 quintuplets were generated, whose distribution is shown in Figure 4 where the key quintuplet centroid distance is also shown. As it can be seen it substantially seated on the mean. Should we have collected a large enough population and the position of the key quintuplet would have divided the distribution in half.

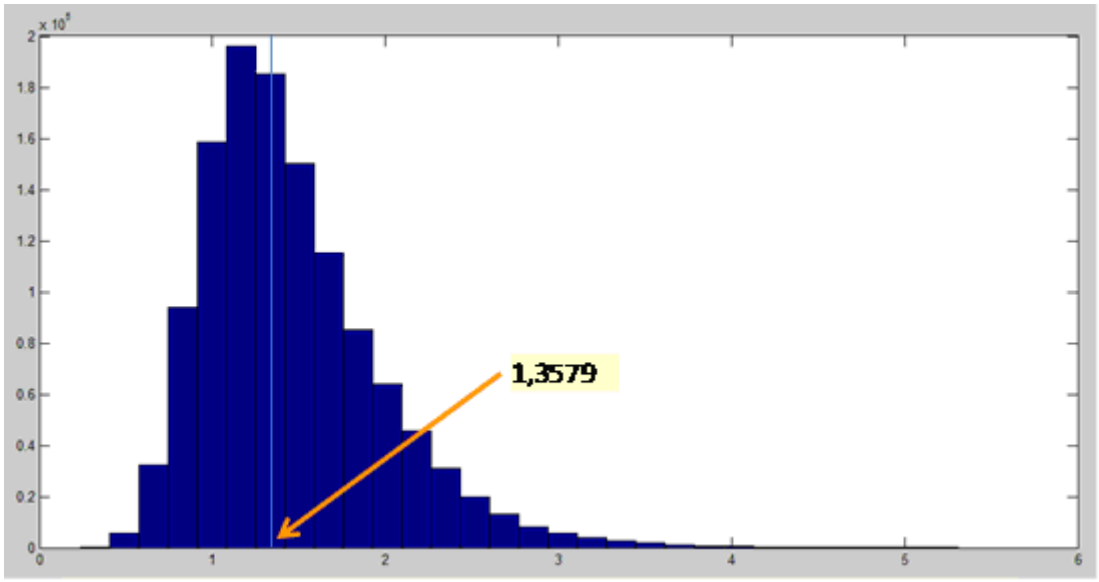

Figure 4: Distribution of quintuplets and position of the key quintuplet

6. CONCLUSIONS

The results showed that the developed methodology was effective for the identification of the social networks of influence that are relevant in the formation of the organization's safety, for the case of IPEN-CNEN-SP. In addition, the methodology can be applied to any organization and can used also for other types of culture. As this approach is unprecedented in the literature, it was kind of pioneer work to identify what issues are most appropriate to identify the key relationships and map the corresponding networks.

We have used seven questions that were grouped giving rise to four networks and a general aggregates networks all four. Throughout his work we see that other ways to configure the networks could be even more effective.

The identification of the leading actors (influencers of opinion and behavior) was made based on various networks, but only the aggregate network was used to make the proof of influence. Cross-analysis of the vector space and of the networks allowed demonstrating that the mapped networks picked up the most influential actors and that this influence is reflected in the vectors that characterize the culture of the population. This gives much encouragement and support for this work to be used by IPEN in programs to improve its safety culture.

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