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BUILDING A COLLABORATORY IN AN ENGINEERING R&D ORGANIZATION

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ABSTRACT

This paper presents the results achieved so far in the process of preparing the ground to develop a collaboratory in an Engineering R&D organization. This case study is part of a broader research project engaged in building a collaboratory in order to share knowledge and resources among the Portuguese State Laboratories. In the process of preparing the ground to develop the collaboratory in the first of the State Laboratories studied, an information audit was conducted and an online survey was launched. The survey targeted 240 people, including mainly professional researchers (c. 160), but also research trainees and some technical staff integrating the research teams. The questionnaire was designed so as to collect data on the information management and information culture of the organization, on the researchers' information needs and information seeking, and on the information flows taking place, and was composed of two distinct and independent parts. The first obtained seventy nine responses, while the second achieved ninety two, corresponding to 33% and 38% of the total sample, respectively. The work carried out will provide the basic requirements for the task of developing an infrastructure and tools for the collaboratory, addressing the various aspects of collaborative software tools, information archiving and intelligent search, remote control of scientific instruments and multi-channel access to the services.

KEYWORDS

Collaboratory; Information audit; Information management; Information culture; Information behaviour.

1. INTRODUCTION

This paper presents the results achieved so far in the process of preparing the ground to develop a collaboratory in an Engineering R&D organization. This case study is part of a broader research project (Correia et al., 2007) engaged in building a collaboratory - understood as a laboratory without walls, in which scientists are connected to each other, to scientific instruments and to data and information, independently of time and location – in order to share knowledge and resources among the Portuguese State Laboratories. The building of the collaboratory is anchored on three main tasks: a) information audits carried out in each of the target organizations, in order to map the main information flows, entities, repositories and systems in each organization; b) information behaviour research, in order to gain insight into the organizational information culture and into the researchers' information-seeking and networking patterns, and to relate them to a number of factors, of an individual nature (such as education/degree or technical discipline), and of an organizational nature (tenure, role played and tasks performed); c) implementation of the appropriate infrastructure and tools, in order to accommodate information archiving and intelligent search, collaborative software tools, multi-channel access, common feel and familiar human interface, and open source software tools-based solutions, whenever possible.

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The process of preparing the ground to develop the collaboratory includes an information audit and the study of the organizational information management and information culture and of the researchers' information needs and information seeking. This last topic (researchers' information needs and information seeking) and the corresponding results are not addressed in this paper.

2. CONCEPTUAL FRAMEWORK

Collaboratories represent a potential transformation of the idea of laboratory (Finholt & Olson, 1997; Finholt, 2005; Sonnenwald et. al., 2004). For scientists and engineers, collaboratories have the potential to "revolutionize what they can do, how they do it, and who participates in what is being done". The capabilities provided by collaboratories are expected to increase the effectiveness of existing resources. Scientists and engineers become able to interact as if they were using the same physical location, sharing data, high-performance computing systems and instrumentation independently of location.

Information auditing is a process of discovery, monitoring and evaluation of an organization's information flows and resources in order to implement, maintain or improve the organization's management of information. In fact, information auditing can be regarded as a critically important information management tool, since it provides detailed and accurate information on the organizational information environment, and an understanding of the information management processes, at personal, operational, organizational and strategic levels (Buchanan & Gibb, 1998; Botha & Boon, 2003). Ultimately, the information audit aims at aligning the organizational information strategy with the organizational business strategy.

Information management can be defined as "the application of management principles to the acquisition, organization, control, dissemination and use of information relevant to the effective operation of organizations of all kinds" (Wilson, 1997:187), while the basic challenge in knowledge management is learning how to design an organization's strategy, structure and systems so that the organization can use what it knows to innovate and adapt (Choo, 1998).

Organizational culture derives from a shared set of values, norms and beliefs that shape the mental framework of the organization members and heavily influence their behaviour. That mental framework provides the lens to interpret the organization's external environment as well as the understanding of what is the right way to deal with whatever challenges are posed to the organization. Information culture, in turn, configures "the socially transmitted patterns of behaviours and values about the significance and use of information in an organization" (Choo et al., 2006:492). Consequently, it is the information culture that guides organization members in assigning significance to new information, and in deciding how to deal with it.

Wilson (2000:49) defines information behaviour as "the totality of human behaviour in relation to sources and channels of information, including both active and passive information seeking and information use". The ways in which information behaviour has been conceptualized and studied have changed profoundly over the last three decades. The most significant influences have been various strains of the sense-making paradigm as well as constructivist models of thought. At present, the dynamic, personal, and context-bounded nature of information behaviour seems to be taken for granted. This rationale suggests that the individual information behaviour is influenced by the organizational information management and information culture.

The concepts we have briefly introduced are core to our conceptual framework and are closely intertwined. Information audit is a key information management tool, while information management is a key element in the configuration of the information use environment (Taylor, 1991) of an organization. On the other hand, information culture embeds the organizational values concerning the significance and use of information, and directly influences the information behaviour of organization members. We believe that all these concepts, and the corresponding organization features, must be taken into account in the building of a collaboratory.

3. METHODOLOGICAL APPROACH

The case study strategy was adopted because it is particularly amenable to the triangulation of methods (in this case, document analysis, survey and interviewing) thus providing rich ingredients to characterize a specific context. The research site is LNEC (Laboratório Nacional de Engenharia Civil), a large government R&D institution founded in 1946. Its main goals are to carry out innovative R&D in the various domains of civil engineering, to contribute to the best practices in the field, and to give advice to the government in technical and scientific matters of civil engineering. The Laboratory has 650 staff (2007), of which 43% hold a university degree and 24% are researchers with a PhD or equivalent qualification. It also has about 80 research trainees with grants awarded by LNEC.

Our online survey targeted 240 people, including mainly professional researchers (c. 160), but also research trainees and some technical staff integrating the research teams. The questionnaire was designed so as to collect data on the information management and information culture of the organization, on the researchers' information needs and information seeking, and on the information flows taking place. The part of the questionnaire addressing the organization's information management and culture incorporates the questionnaire used by Choo et al. (2006), since it was thought appropriate to replicate this study.

4. RESULTS

4.1 Profile of the Respondents

The questionnaire used in the online survey had two distinct and independent parts. The first obtained seventy nine responses, while the second achieved ninety two, corresponding to 33% and 38% of the total sample, respectively. The great majority of the respondents is between 36 and 55 years old (73,4%) and is male (63,3%). Most of them (53%) are PhD or equivalent, mainly in the Engineering Sciences field, with particular incidence in Civil Engineering. Sixty-seven percent (67%) are professional researchers, while the remaining are research trainees and technicians. Seventy-six percent of the respondents work in the organization for more than ten years. We obtained responses from all the departments and from two of the three technical-scientific centres.

4.2 Information Audit

4.2.1 Alignment between Work Effort and Strategic Objectives

The information audit was designed as a three-step approach addressing the institutional level, the department level, and the individual level. At the institutional level, we interviewed members of the directive board in order to identify the main organizational processes and their alignment with the organization strategic objectives. At the departmental level, we arranged for a group meeting with the heads of each organizational unit to discuss, check and validate a model of "how the organization is viewed from the outside", which was prepared in advance based upon the results gathered from the first step, together with information publicly available about the organization. The survey was then developed on top of the results from these two previous steps. At the individual level, we used the survey to enquire researchers, research trainees and technicians integrating the research teams, to identify internal and external information flows, information sources and systems in use, perceived needs, and the alignment of tasks with those systems and flows.

One of the goals of the information audit was to analyse the correlation between the strategic activities and the actual work effort in the organization. We identified five strategic activities that were defined by the Laboratory's organization norms. These were: programmed research, studies, promotion of construction quality, dissemination of scientific knowledge, and cooperation with other entities. The survey enquired how much effort was dedicated to each of these strategic activities in order to assess the alignment between the effective work done by researchers and the organization mission and objectives.

We had ninety-two answers, and table 1 bellow allows us to draw several conclusions. Not all the strategic activities have the same weight in terms of work done in the organization. For example, more than

half of researchers do not focus on the promotion of construction quality, and from those who do, their efforts are limited to 20%. We can see that dissemination of scientific knowledge is a strategic activity done by more than 70% of researchers, although their effort is also not greater than 20%. We can also see that the two main strategic activities in terms of effort are programmed research, and studies, but their distribution differs. Forty percent (40%) of the researchers do not dedicate more than 30% of their time to programmed research, but in the case of studies, the distribution is much more spread out, with 10% of the researchers answering that half of their work is related to this strategic activity.

Table 1. Staff Dedication to Strategic Activities

Percentile to choose from	Programmed Research	Studies	Promotion of Construction Quality	Dissemination of Scientific Knowledge	Cooperation with external entities
0%	21.7%	23.9%	54.3%	26.1%	31.5%
10%	8.7%	6.5%	22.8%	40.2%	45.7%
20%	20.7%	13.0%	12.0%	23.9%	9.8%
30%	26.7%	18.5%	6.5%	6.5%	3.3%
40%	9.8%	17.4%	1.1%	1.1%	4.3%
50%	3.3%	10.9%	0.0%	1.1%	2.2%
60%	3.3%	5.4%	2.2%	0.0%	2.2%
70%	4.3%	3.3%	0.0%	1.1%	0.0%
80%	2.2%	0.0%	1.1%	0.0%	1.1%
90%	0.0%	1.1%	0.0%	0.0%	0.0%
100%	0.0%	0.0%	0.0%	0.0%	0.0%

4.2.2 Perceived Systems Characteristics

The same survey also allowed to collect some information on the use of systems and applications within the Laboratory. Most, if not all researchers make use of common office applications together with specialized software packages for scientific computing, signal processing, simulation and control, etc. There are also several special-purpose databases. Researchers have frequently the need to share data among themselves and also to exchange data with external entities. These needs expose several limitations of those systems as far as collaboration is concerned. Figure 1 lists the most recurring problems as reported by the respondents. About 45% of researchers complain about the systems being slow, and this performance issue seems to be the main problem. However, all the other problems being pointed out are effectively connected with issues that can negatively affect collaboration – the inability to export data, the need to support departmental activities, the lack of traceability and the lack of information structure are some examples of issues that must be addressed and overcome by a new information infrastructure to support the collaboratory.

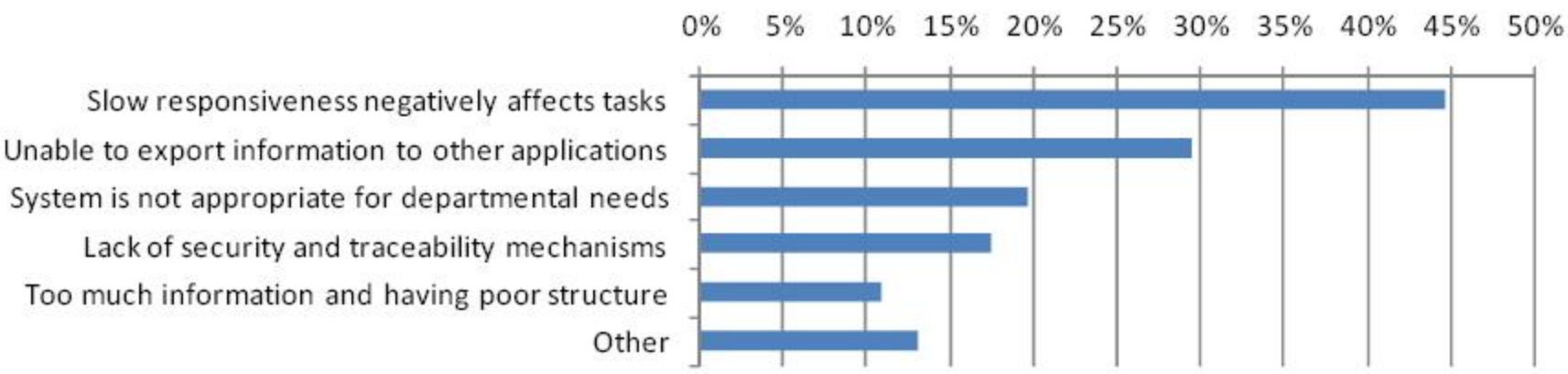

Figure 1. Systems Characteristics

4.3 Information Behaviour

4.3.1 Information and Knowledge Management

As mentioned before, our rationale suggests that the individual information behaviour is influenced by the organization information and knowledge management. Our survey envisaged to identify the perceptions of the respondents concerning key aspects in this area. Table 2 presents the mean scores of the items in both dimensions (IM and KM) of the variable "Information and Knowledge Management" (IKM). The mean

scores show that the respondents tend to agree moderately with the given statements about information management in the organization (in a scale from [1] strongly disagree, to [5] strongly agree), although they seem to disagree with the statement "Information about good work practices and experts is easy to find in my organization". Generally speaking, the respondents agree more strongly with the items concerning knowledge management, even though they tend to disagree with the statement "My organization has formal procedures to collect and share knowledge".

Table 2. IM and KM Descriptive Statistics

	N	Mean	SD
Information management		3.15	0.697
My organization has a formal policy or strategy for managing information.	79	3.08	0.931
My organization identifies and obtains information from outside sources (e.g. government agencies, companies, universities).	79	3.49	0.918
In my organization information is available and organized in a way that it is easy to find what I need.	79	2.94	0.979
Information about good work practices and experts is easy to find in my organization.	79	2.78	1.058
My organization makes use of information technology to facilitate information sharing.	79	3.48	0.918
My organization has a culture intended to promote information sharing.	79	3.15	1.001
Knowledge management		3.39	0.764
My work unit encourages experienced workers to communicate their knowledge to new or less experienced workers.	79	3.61	1.103
My organization encourages workers to attend training courses and conferences.	79	3.52	0.890
My organization has formal mentoring programs and/or apprenticeships for beginning researchers.	79	3.41	0.994
My work unit has a culture intended to promote knowledge sharing.	79	3.49	1.048
My organization has formal procedures to collect and share knowledge.	79	2.91	1.028

This means that the research staff of the organization is moderately satisfied with the way information is managed in the organization, and slightly more satisfied with knowledge management. However, KM seems to be grounded mainly on person-to-person exchange processes, such as mentoring and apprenticeship, and less on formal organizational processes. This is consistent with the traditional way of doing things in the Engineering field, namely the relation established between senior and junior professionals, and the training and socialisation of new professionals.

4.3.2 Information Culture

The variable "Information Culture" is characterized by six dimensions or information values: integrity, transparency, sharing, proactiveness, formality and control (Marchand et al., 2001). Table 3 shows the mean scores of responses concerning statements about information culture (values and associated behaviours) on a scale from [1] strongly disagree to [5] strongly agree. The scores indicate agreement with all the items on integrity (if reverse-coded, the mean would be 3,57) and on transparency (with "Managers and supervisors of my work unit encourage openness" scoring the highest level of agreement: 3,67). The scores also indicate agreement with most items on sharing (with the exception for "I often exchange information with people outside my organization", scoring 2,99), but with the strongest agreement for "I often exchange information with the people with whom I work regularly", scoring 4,22), on proactiveness (with the exception for "My organization encourages workers to seek out relevant information on changes and trends going on outside the organization", scoring 2,89) and on control. As for (in)formality, informal information sources play clearly a subsidiary role in relation to formal information sources, which are much praised by the respondents.

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Table 3. Information Culture (Values and Associated Behaviours) Descriptive Statistics

	N	Mean	SD
Integrity (reverse-coded)		2.43	0.893
Employees know what to do but not the ultimate goal of their activity.	79	2.38	1.054
Among the people I work with regularly, it is common to distribute information to justify decisions already made.	79	2.78	1.034
Among the people I work with regularly, it is normal for individuals to keep information to themselves.	79	2.58	1.205
Among the people I work with regularly, it is normal to leverage information for personal advantage.	79	2.33	1.152
Transparency		3.49	0.887
Managers and supervisors of my work unit encourage openness.	79	3.67	1.022
The people I work with regularly share information on errors or failures openly.	79	3.34	1.085
The people I work with regularly use information on failures or errors to address problems constructively.	79	3.46	1.035
Sharing		3.47	0.752
I often exchange information with the people with whom I work regularly.	79	4.22	0.872
I often exchange information with people outside of my regular work unit but within my organization.	79	3.34	1.108
In my work unit, I am a person that people come to often for information.	79	3.33	0.916
I often exchange information with people outside my organization.	79	2.99	1.068
Proactiveness		3.27	0.783
My organization encourages workers to seek out relevant information on changes and trends going on outside the organization.	79	2.89	1.109
I use information to respond to changes and developments going on outside my organization.	79	3.32	0.927
I use information to create or enhance my organization's systems, services, and processes.	79	3.59	0.899
(In)formality		-	-
I trust informal information sources (e.g. colleagues) more than I trust formal sources (e.g. memos, reports).	79	2.29	0.908
I use informal information sources (e.g. colleagues) extensively even though formal sources (e.g. memos, reports) exist and are credible.	79	2.53	1.048
I use informal information sources (e.g. colleagues) to verify and improve the quality of formal information sources (e.g. memos, reports).	79	3.28	1.061
Control		-	-
I receive information about the performance of my organization.	79	3.35	1.063
My knowledge of organizational performance influences my work.	79	3.10	1.139
In my organization, information is essential to organizational performance.	79	3.41	0.981
Information in my organization is distributed on a "need to know" basis.	79	2.91	1.157
Employees know what to do but not the ultimate goal of their activity.	79	2.25	1.006

These results suggest that this organization's information culture is characterized by a high level of integrity and transparency in the use of information, which is consistent with the ethos of an R&D organization. It is also characterized by formality in the use of information, and by the importance attributed to sharing information, mainly internally. These two last features may be explained by the large dimension and the unique role played by this government institute, which is a national authority consulted by government bodies on matters such as the location of the new Lisbon Airport, the feasability study of the High Speed Railway (Rede Ferroviária de Alta Velocidade) in Portugal, or the development of the massive Alqueva dam. A closer analysis of the items on proactiveness reinforces the image of a somewhat inward-

looking organization, with the item "My organization encourages workers to seek out relevant information on changes and trends going on outside the organization", scoring only 2,89.

4.3.3 Information Use Outcomes

Information use "occurs when the individual selects and processes information which leads to a change in the individual's capacity to make sense or to take action" (Choo at al., 2006:495). Based on Taylor (1991), Choo et al. (2006) generated three categories that consubstantiate the outcomes of information use: a) task performance (includes the use of information to make sense of a situation, understand a problem or learn how to use a tool); b) self-efficacy (includes the use of information to sustain personal involvement, enhance status or reputation, or personal fulfilment); c) social maintenance (includes the use of information to develop relationships and get connected to others). Table 4 displays the mean scores of respondents who indicate their agreement with five items about information use outcomes, on a scale from [1] strongly disagree to [5] strongly agree. The scores indicate a strong agreement with the three items concerned with task performance (with a mean of 3,65), a very strong agreement with the item concerned with self efficacy ("work benefits the organization" scores 4,01) and an even stronger agreement with the item concerned with social maintenance ("information sharing is critical…" scores 4,18).

Table 4. Information Use Outcomes Descriptive Statistics

	N	Mean	SD
Information use outcomes		3.83	0.526
I can solve the problems inherent to my work tasks.	79	3.95	0.749
My work tasks demand new, creative ideas and solutions.	79	3.97	0.816
My work benefits my organization.	79	4.01	0.670
I have influence over what happens within my work unit.	79	3.05	0.918
Sharing information is critical to my being able to do my job.	79	4.18	0.874

At this point, it is appropriate to remind that information use generates either a change in the individual's capacity to make sense or to take action. These results suggest that the research staff of this organization acknowledge that change occurs in these two spheres: changes in their capacity to make sense ("I can solve the problems inherent to my work tasks"; "My work tasks demand new, creative ideas and solutions") and changes in their capacity to act ("I have influence over what happens within my work unit"; "Sharing information is critical to my being able to do my job").

5. CONCLUSIONS

The information audit carried out in this Engineering R&D organization allows to identify systems' features, as perceived by the respondents, that can negatively affect collaboration. The inability to export data, the need to support departmental activities, the lack of traceability and the lack of information structure are some examples of issues that should be addressed in the development of the information infrastructure to support the collaboratory.

The analysis of the researchers' perceptions concerning the organization information management, shows that the research staff is only moderately satisfied with the way information is managed in the organization. There seems to be ground for improvement in this area. In what concerns knowledge management, the research staff regards very positively the knowledge management processes based on person-to-person exchange, such as mentoring and apprenticeship, but is less satisfied with formal organizational processes of knowledge collection and sharing. The collaboratory platform and tools may help implementing more formal procedures.

The analysis of the respondents' perception of the organizational information culture reveals a culture characterized by a high level of integrity and transparency in the use of information, which is consistent with

the ethos of an R&D organization. But it also reveals a somewhat inward-looking culture, that we attribute to the unique role played by the organization, but which can slide into a dangerous notion of self-sufficiency. The collaboratory may provide the means to open up the organization and its community of researchers to external research communities.

From these results, and others that we could not report here due to limitations of space, we expect to derive a set of requirements for the development of an infrastructure and tools for the collaboratory, addressing the various aspects of collaborative software, information archiving and intelligent search, remote control of scientific instruments, multi-channel access to the services, etc. In the meantime, and as a consequence of this study, the Laboratory is already pursuing, in an informal manner, the actual "hands-on" use of what can be seen as collaborative tools and the features that were considered desirable.

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