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The implementation process of knowledge management at the Institute of Radiation Protection and Dosimetry: actions and perspectives

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ABSTRACT

The Institute of Radiation Protection and Dosimetry (IRD) is a research and development institution, linked to the Brazilian Nuclear Energy Commission (CNEN), with a tradition of training human resources in the areas of radiation protection, dosimetry, medical physics and metrology of ionizing radiation. Despite this relevance, the IRD has suffered loss of its intellectual capital, mainly due to retirements and lack of replacement of qualified personnel. Thus, it is extremely important to preserve the technical-scientific knowledge related to its activities. A methodology that can help in this process is knowledge management (KM), in view of its potential to generate benefits in public and private organizations. Therefore, this work aims to carry out an experience report of the process of implementing KM at IRD, which used as a theoretical reference the models applied by the International Atomic Energy Agency (IAEA). Initial results include the creation of the working group on KM, the diagnosis of critical knowledge and maturity, the Knowledge Management Assistance Visit (KMAV) by IAEA and the production of papers. In addition, the support of the IRD's top management should be highlighted, which has made it possible to carry out activities related to the implementation and effectiveness of KM. Thus, it is intended to expand KM activities in the IRD, such as the execution of projects and the offer of training in the area.

Keywords: **nuclear knowledge management, implementation process, Institute of Radiation Protection and Dosimetry (IRD), International Atomic Energy Agency (IAEA).**

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1. INTRODUCTION

The Institute of Radiation Protection and Dosimetry (IRD) is a research and development institute, being considered a national and international reference center in the area. Linked to the Brazilian Nuclear Energy Commission (CNEN), the IRD works in collaboration with universities, government agencies and industry to promote the safe use of ionizing radiation and nuclear technology [1].

The IRD has a tradition in the training of human resources through its Postgraduate Educational Program in Radiation Protection and Dosimetry (at Master and Doctorate levels) – in the areas of Metrology of Ionizing Radiations, Medical Physics, Biophysics and Radioecology – and the Postgraduate Educational Course (PGEC) in Radiation Protection and the Safety of Radiation Sources, offered in partnership with the International Atomic Energy Agency (IAEA), since it is the Regional Training Center for Portuguese speaking countries [2].

In addition to these activities, IRD offers regular short-term courses and trainings, and is also responsible in the country for maintain, develop and disseminate national standards of radioactive sources and prepare personnel, in an integrated manner, to respond, at national and international level, to possible radiological emergencies [2].

Despite its relevance, the IRD has suffered in recent years a loss of its specialized intellectual capital, either due to the high number of retirements the lack of replacement of qualified personnel, which can compromise the execution of a large number of activities.

To mitigate this loss of critical institutional knowledge, the IRD Board has supported a series of initiatives in view of the importance of preserving the technical-scientific knowledge related to its activities. And one of these initiatives was the implementation process of the Knowledge Management (KM), once KM has the potential to generate several benefits in public and private organizations, such as achieving objectives, increasing innovation and competitiveness, generating, retaining and disseminating knowledge [3].

It is essential then to carry out processes that involve education, qualification and training of human resources, always aiming at the transfer of knowledge [4]. The understanding of KM must be that according to which strategic information is identified, analyzed and interpreted in order to generate new information and knowledge that support the decision-making and action processes [5-7].

Thus, Nuclear Knowledge Management (NKM) is extremely important for the development and preservation of the knowledge and skills necessary for the execution of activities related to the nuclear

area. In this regard, for the IAEA, the importance of the NKM would be that building, collecting, transferring, sharing, preserving, maintaining and using knowledge is essential to develop and maintain the necessary technical knowledge and skills required for nuclear power programs and other nuclear technologies, as advanced and specialized knowledge in nuclear engineering and science is essential for the safe and effective design, construction, licensing, commissioning, operation, maintenance and decommissioning of nuclear technology-based systems, which have long life cycles [8; 9].

Therefore, recognizing the importance of NKM, the IAEA develops methodologies and guidance documents to plan, design and implement NKM programs and facilitate nuclear education, providing support, networking opportunities and exchange of experiences [8; 9].

The IAEA assists Member States by providing products and services to maintain and preserve nuclear knowledge and by promoting the use of state-of-the-art knowledge management technologies, as in the case of radiation protection, a set of measures designed to protect human beings, their descendants and the environment against possible undue effects caused by ionizing radiation from technologically modified natural sources and sources [8; 9].

2. **MATERIALS AND METHODS**

This paper aims to carry out an experience report [10] of the NKM implementation process in a nuclear public organization unit (IRD), describing the steps and assets (products and results), as well as pointing out future activities. Thus, a brief history will be carried out, demonstrating its stages and some of its products and results.

The implementation of NKM at IRD followed the precepts contained in the "IAEA-TECDOC-1675", entitled "Knowledge Management for Nuclear Research and Development Organizations" [11], using its definitions, guidelines, methods and models. In this TEC-DOC-1675, can be found information about some KM methodologies as: Management Strategy ("Up/Down"; "Push/Pull"); Map of Competencies; Concept Maps; Maturity Assessment; Key Performance Indicators (KPIs) and Lessons Learned.

3. RESULTS AND DISCUSSION

The IRD has developed institutionally a series of actions aimed at implementing the NKM, as will be shown chronologically below.

3.1. First steps – NKM School

The beginning of awareness and the first technical contact in NKM by the staff of the IRD occurred from the participation of some employees, since 2015, at the School of Nuclear Knowledge Management, which is an annual course offered by the IAEA in partnership with the International Center for Theoretical Physics Abdus Salam (ICTP) [12].

This School is a certified course that provides specialized education and training in the development and implementation of KM programs in core organizations. The IAEA also offers regional courses, which already had the participation of IRD employees. The school is taught by IAEA experts with recognized expertise and focuses on methodologies and practices, and explores various dimensions of KM [12].

The main topics covered are: KM Fundamentals; Development of Policies and Strategies of NKM; Managing Nuclear Information Resources; Human Resources Development; Risk of Loss of Knowledge and Transfer of Knowledge; and Practical Guidance and Good Practices on KM [12].

The learning is complemented with real and successful examples of KM programs in different countries, and one of the main objectives is to encourage and enable participants to apply KM in their respective institutions. These participations were crucial for learning about NKM and the transposition of ideas and practices to the IRD.

3.2. Ph.D.

In 2015, a doctoral thesis entitled "Sociotechnical modeling of a nuclear organization: a case study applied to the National Laboratory of Metrology of Ionizing Radiation" [13] was defended by the employee of the IRD Maria Elizabeth Dias Acar, in the Postgraduate Program in Nuclear Technology from the Institute for Energy and Nuclear Research (IPEN).

In this thesis, a methodology combining process mapping and analysis; knowledge elicitation mapping and critical analysis; and sociotechnical analysis based on social network analysis was conceived.

The methodology was applied to the National Laboratory of Ionizing Radiation Metrology (LNMRI), a small knowledge intensive organization, and has allowed the appraisal of the main intellectual assets and their ability to evolve. In this sense, based on real issues such as attrition, the impacts of probable future scenarios were assessed. For such task, a multimodal network of processes, knowledge objects and people were analyzed using a set of appropriate metrics and means, including sphere of influence of key nodes [13].

To differentiate the ability of people playing roles in the processes, some nodes attributes were used to provide partition criteria for the network and thus the ability to differentiate the impact of potential loss of supervisors and operators. The proposed methodology has allowed for: i) the identification of knowledge objects and their sources; ii) mapping and ranking of these objects according to their relevance and iii) the assessment of vulnerabilities in LNMRIs network structure and iv) revealing of informal mechanisms of knowledge sharing. The conceived methodological framework has proved to be a robust tool for a broad diagnosis to support succession planning and also the organizational strategic planning [13].

3.3. Awareness Process– The 1st Brazilian School of NKM

The IRD, in partnership with the IAEA, promoted the 1st Brazilian School of NKM, between December 5 and 9, 2016. The objective was to provide specialized training for professionals who have or can play a leading role in the development and implementation of knowledge management programs in nuclear science and technology organizations [14].

Held at the IRD headquarters in Rio de Janeiro, the School brought together 48 professionals from various institutions in the nuclear sector, universities and companies, after a selection of 150 applicants [14].

The training, entirely free of charge, was given by experts from the country and abroad invited by the IAEA. The students learned about available KM tools, discussed knowledge loss risk analysis and knowledge transfer and inter-organizational networks, among other topics. They also had the opportunity to assemble mini-projects in groups, based on real scenarios [14].

3.4. Creation of the Knowledge Management Working Group (KM-IRD)

In 2019, Ordinance IRD nº 30, of April 15, was edited, instituting the group aimed at creating a KM project (KM-IRD) aimed at retaining, preserving and transferring knowledge within the scope

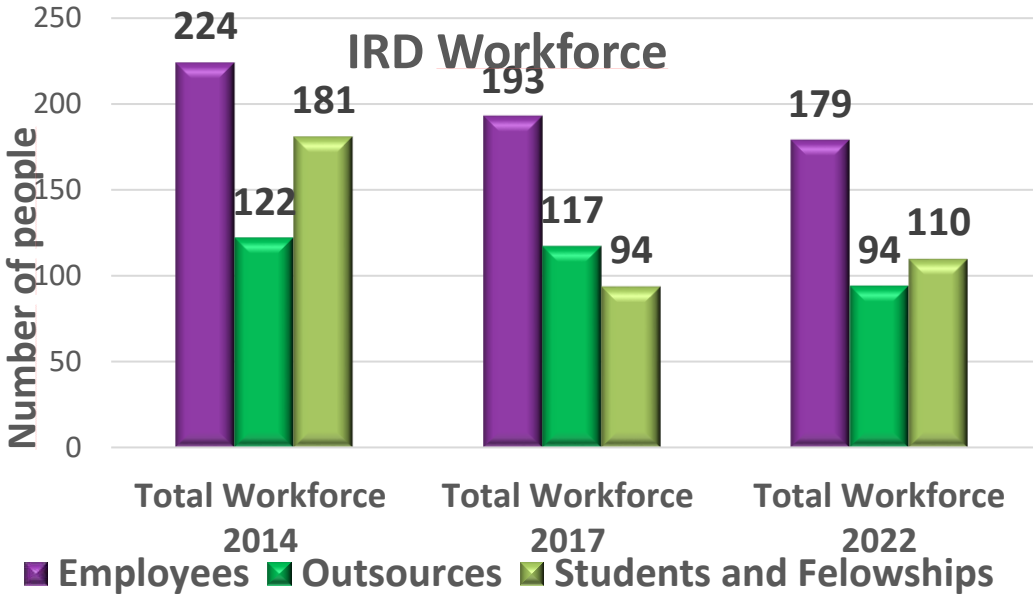
of the IRD, using as based on the precepts of the International Atomic Energy Agency (IAEA). Currently, the KM-IRD is composed of 5 employees:

- ✓ 1 from Information Technology (IT) area;
- ✓ 1 from Human Resources (HR) area;
- ✓ 1 from Teaching and Training area;
- ✓ 1 from Management area;
- ✓ 1 from Finalistic/Techincal area.

3.5. Mapping the Critical Knowledge of IRD

The CNEN and its respective institutes, such as the IRD, have been facing, over the years, a reduction in the number of employees, causing a significant loss of institutional knowledge. This is mainly due to the aging of the workforce (due to retirement), the departure of employees to work in other areas and the lack of public tenders (Figure 1).

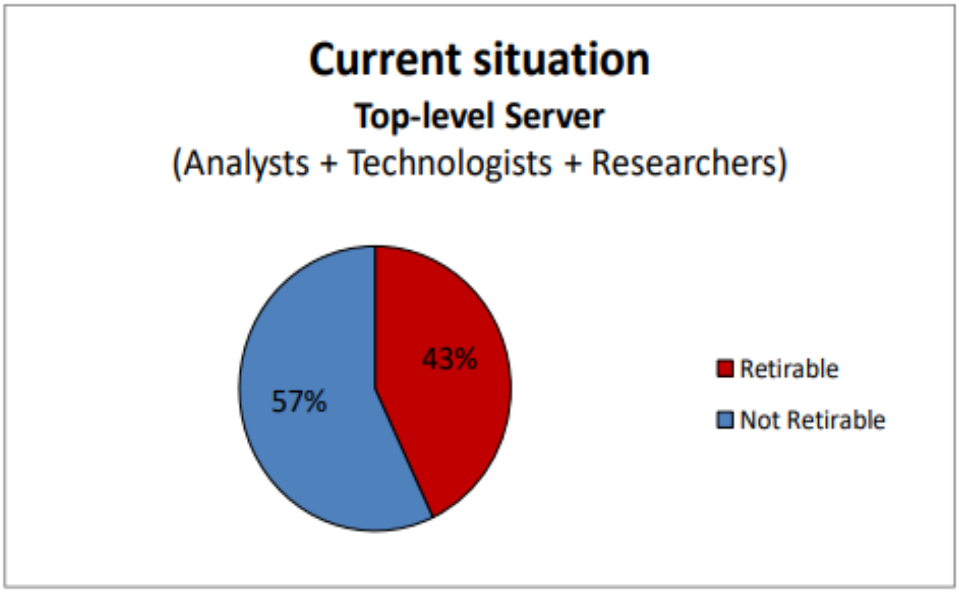
Figure 1: *Evolution of IRD workforce loss in recent years.*



Source: [1].

It can be mentioned that, in 2022, there were 179 permanent employees linked to the IRD (in addition to 94 service providers and 110 students – both cases of temporary employees). Of this total of 179, 100 were already eligible for retirement. In addition, the IRD presented, in the year 2022, an average age among its effective employees of 57 years (Figure 2).

Figure 2: *Current situation of top-level employees at IRD.*



Source: [1].

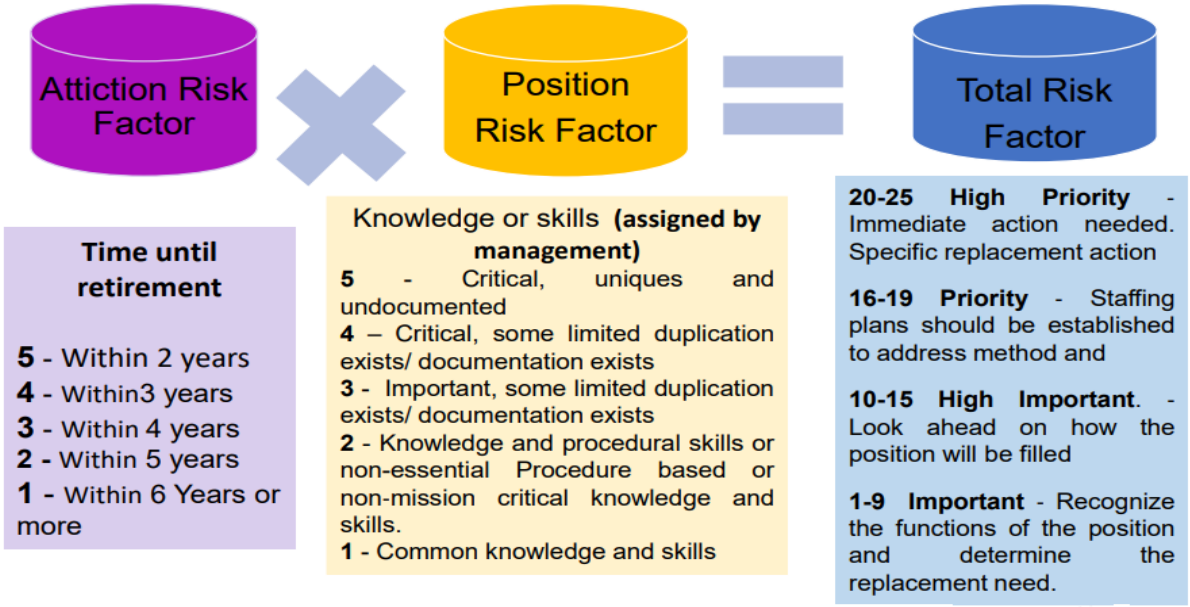
Thus, the departure of these employees can generate a loss of intellectual capital and critical knowledge about the technologies, experiences and knowledge acquired, given that they are often not sufficiently documented, preserved and transferred. A work was then carried out with the IRD in order to map the critical areas threatened by the loss of critical knowledge, due to both the specificity of the knowledge and the required skills and the difficulty of recovering this type of knowledge.

To map the critical knowledge of retired IRD employees, the model used by the IAEA (2006) [15] was used as a basis, which has the advantage of immediately identifying where there is a greater risk of losing critical knowledge. In this model, the so-called Dropout and Position Risk Factors are considered.

The Dropout Risk Factor is based on the employee's projected retirement time, as described in Figure 3 [16]. The Position Risk Factor depends on the manager's analysis, that takes into account the employee's unique knowledge and skills, in addition to estimating the degree of difficulty or level

of effort required to replace the position, as shown in Figure 5 [16]. Thus, multiplying the Dropout Risk Factors by the Position Risk, one arrives at the Total Risk Factor and its meanings (Figure 3).

Figure 3: *Risk assessment for critical knowledge loss*



It is therefore important to know how many of these employees who retire have the critical knowledge to carry out essential activities for fulfilling the IRD's mission. Factors such as: the time for the employee to leave; the knowledge and technical capacity of the employee; and the availability of replacement personnel with knowledge and skill.

The IRD had 108 higher-level employees, including 28 analysts, 26 researchers and 54 technologists. Of this total, 46 employees have already met the prerequisites for retirement (Figure 4). The figure 4 also shows the distribution of employees according to work area.

For these 46 employees, a score of 5 was assigned to the Abandonment Risk Factor. At the same time, the Director of the IRD, based on Figure 4, attributed the score to the Position Risk Factor for each of these employees.

Regarding the IRD's final area (technologists and researchers), there is an imminent risk of losing 40% of highly qualified personnel (Figure 5).

Figure 4: *Imminent risk of losing highly qualified personnel*

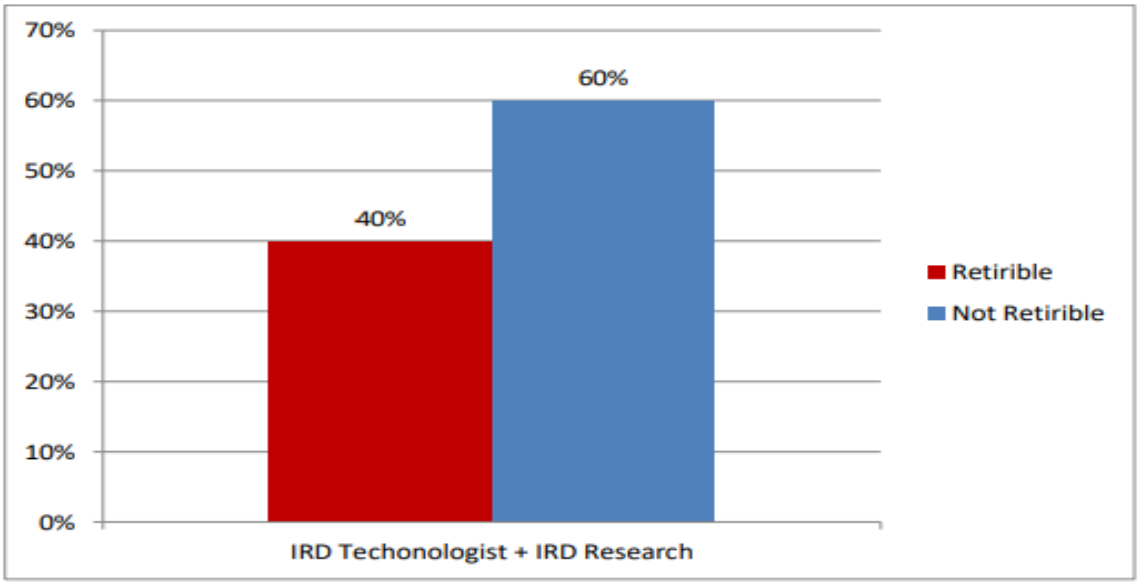
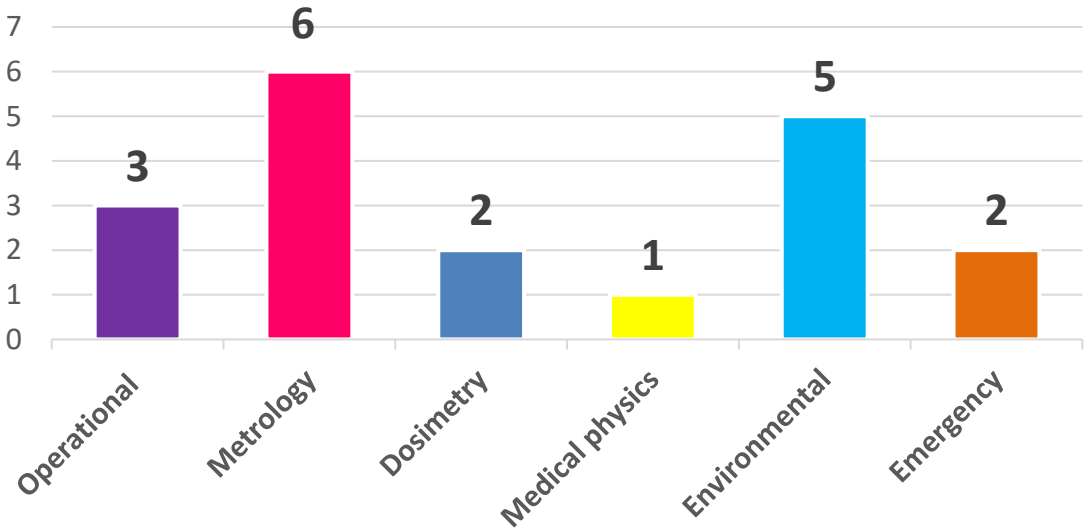


Figure 5: *Mapping through the work.*



3.6. Knowledge Management Assistance Visit (KMAV)

In 2021, the Knowledge Management Assistance Visit (KMAV) was requested from the IAEA. KMAV is an integrated service designed to help Member States maintain and preserve knowledge in core organizations by reviewing established KM practices and providing expert advice on further improvements. Thus, upon official request from a Member State, an international team of experts

formed by the IAEA provides expert opinion and advice, based on IAEA standards, technical guidance and international best practices. The service can be provided through three different levels, depending on an organization's knowledge management needs:

- Level 1 (KM Awareness and Guidance – intended for organizations with a very basic level of KM program or that do not have such a program);
- Level 2 (KM Implementation and Roll-Out – for organizations that have identified their KM objectives and need further assistance in implementing KM tools and techniques); and
- Level 3 (Specialized Assistance in Knowledge Management - is the intervention level that includes specialized training activities, mentoring and provides high-level specialist assistance in specific areas of KM). In the case of the IRD, the visit was carried out at level 2.

A pre-meeting was held with the IAEA KM Coordinators to report on the KM's experience in the IRD and ensure the appropriate level of the visit. In April 2021, the first leg of the visit took place, where a two-day Webex-based online meeting took place to provide guidance and knowledge of beneficial and effective KM programs. Employees from all CNEN institutes that had some activity in KM participated.

Some of the participants had previously attended one of the IAEA's NKM Schools. The IAEA experts gave a broad conceptual and methodological presentation on KM practices, such as assessing the risk of loss of knowledge and loss of critical skills; execution of Mentoring and Coaching processes; approach to the development of KM policies and strategies; succession planning and talent management; the presentation of the Knowledge Management Maturity Self-Assessment Tool; KM implementation milestones, including roles and responsibilities for KM; and techniques for capturing and preserving knowledge.

3.7. Maturity Assessment Tool

To assess the level of maturity of KM at IRD, a tool developed by the IAEA was applied [17]. This tool can be found at IAEA TECDOC SERIES 1880. The self-assessment methodology is a tool to help identify strengths and development areas in the organization’s overall KM strategy and it has 8 (eight) categories as described below:

1. Policy & Strategy For KM – This category addresses the need for a knowledge management system to have a written policy and implementation strategy, as well as the need to establish the responsibilities and attributions involved. Policies are typically statements of intent or commitments

to specific goals or desired outcomes. Strategies and actions to comply with this policy must be established, monitored and evaluated in terms of their effectiveness.

2. HR Processes for KM – This category addresses strategic workforce planning to ensure that current and future human resource needs are met. In addition to succession planning, risk assessment of loss of critical knowledge, recruitment, exit interviews conducted when people leave the organization, and personnel development plans for KM are tools to ensure that an organization maintains a skilled workforce.

3. Training & Competence Development for KM – This category is related to the use of a systematic approach to training that includes knowledge management; Competencies; Coaching and mentoring; Use of simulators for training; Training in virtual environments (e-learning); Training for professional updating and improving of professional performance.

4. Methods, Procedures & Documentation Processes for Improving KM – This category deals with document management systems and processes, including creating, editing, producing, storing, indexing, and disposing of documents. This usually refers to electronic documents and uses specific software for document management.

5. Technical Solutions for KM – This category addresses the application and integration of strategies, systems and information technologies (IT) that support knowledge management. These IT technologies and systems include databases, document and content management systems, the use of the Internet and social networking technologies - Access to scientific information such as scientific libraries, journals and databases); tools to capture and transfer knowledge; concept maps; content management; knowledge repository; portals; Yellow pages; wikis and blogs, among others.

6. Approaches to Capture/Transfer of Knowledge – This category addresses the identification, analysis, capture and dissemination of knowledge that is critical for the Organization, which involves taxonomy development; critical knowledge identification processes; knowledge collection processes; interviews; concept maps; communities of practice; “coaching” and “mentoring”; video capture; workplace training and storytelling.

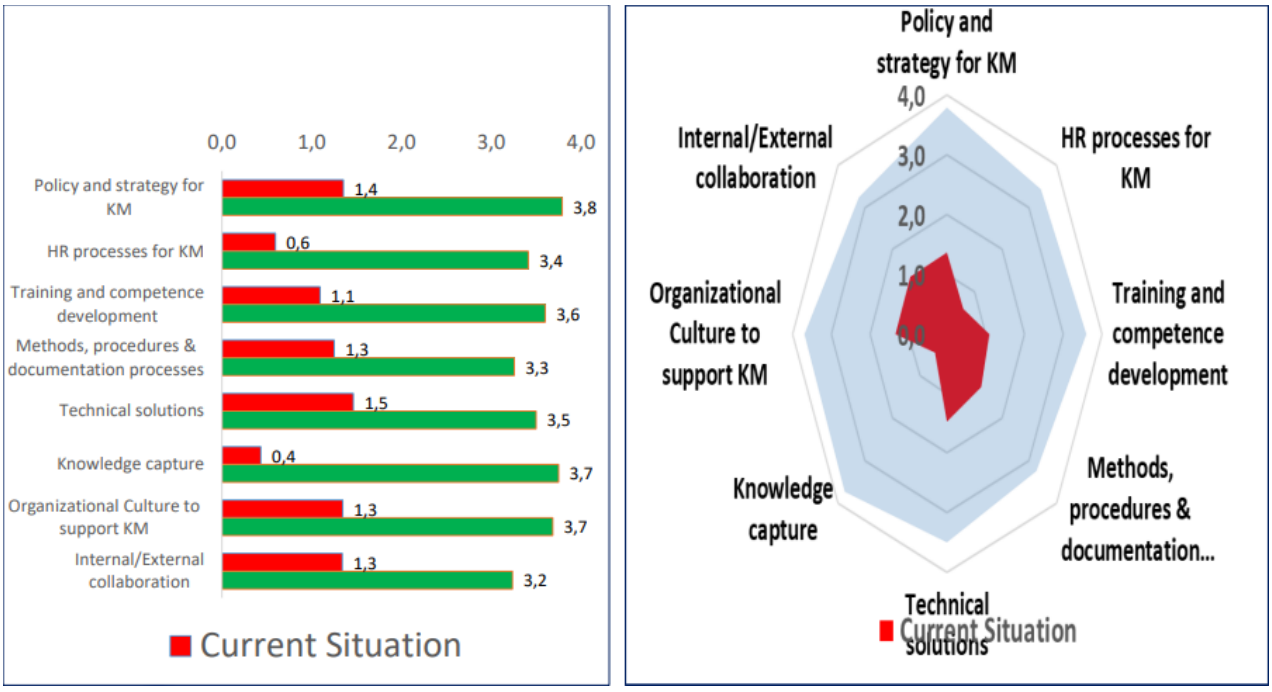
7. Organizational Culture to Support KM – This element addresses the practices, behaviors and attitudes that exist within an organization that together demonstrate the value placed on knowledge that lead to a high level of knowledge sharing. Trust, openness and active collaboration are hallmarks of a positive knowledge management culture.

8. Internal/External Collaboration for KM – This category evaluates the Organization in relation to its collaboration and participation activities with internal and external bodies and networks involving universities; exchanges with educational institutions; conferences; joint research projects; communities of practice; joint seminars and other national and international R&D institutions.

This tool was translated and adapted for application in the IRD in partnership with the IAEA. It has been applied in a group of pre-selected servers according to the affinity with each category. Following the IAEA methodology, each of the eight categories were answered by 10 respondents qualified to carry out the assessment of the aspect being evaluated.

The analysis of the results is based on the difference (Δ Score) found between the current score and the desired score (Figure 6). This gap can vary from 0 to 5, so that the higher the score, the greater the difference between the current situation and what is desired to be achieved. In this way, the highest scoring categories are those where the greatest KM efforts should be prioritized (Figure 6). This work reveals two relevant aspects to be addressed as strategic institutional objectives: (a) Human Resource Processes for KM and (b) Knowledge Capture.

Figure 6: *Scores reported by categories considered to assess the level of KM maturity at IRD*



3.8. Information Technology (IT) and Knowledge Organization Systems (SOC)

On the institutional webpage of IRD (https://www.gov.br/ird/pt-br) it is possible to find information on procedures, documents, forms, works and articles (explicit knowledge).

In addition, it is possible to find on the institutional webpage of IRD on YouTube (https://www.youtube.com/channel/UCNTqRGwvdZDU5PaqojsJdSg) interviews and lectures on various subjects related to the area of radiation protection and dosimetry.

3.9. Other Activities

Although there is no structured and implemented Mentoring program, some management positions are currently filled by senior professionals and, whenever possible, they work directly with younger employees with high potential for success.

Despite this, in 2021 the first Mentoring project was started, carried out in the Environmental Protection Division. In addition, could be mentioned the publication of papers, addressing the themes of KM, as lessons learned [9], conceptual maps [5], critical knowledge [4, 15], and scientific knowledge management [18-20].

4. CONCLUSIONS

It can be said that with these activities, the KM-IRD and some IRD employees could be introduced into available KM tools, serving as a basis for the discussion of the risk analysis of knowledge loss and the transfer of knowledge and inter-organizational networks, among other topics.

Some achievements can be highlighted, such as the implementation of the KM-IRD; carrying out the Maturity Self-Assessment; the preliminary analysis to identify gaps in an organization's KM program/activities; holding Awareness Meetings with Managers; the identification of employees with Critical Knowledge; and the KM Implementation Program is in the final stages of elaboration.

The Level 1 of the visit was very useful to discuss specific issues for the IRD, allowing an exchange of experiences and commitment to the next steps of the process.

The Risk assessment for critical knowledge loss identified 19 technical area employees with high priority risk factors. Fortunately, all these areas are covered by research lines in IRD postgraduation

programs, as they can transfer their knowledge during classes. This initiative seems to minimize the effect of loss of knowledge.

The Maturity assessment for KM in the IRD was very helpful to discuss specific issues for the Institute and to guide the development of a knowledge management program for the IRD. The identification of KM practices to benefit and improve existing KM activities to support the organization's objectives is achieved. A study has already been carried out to identify the holders of critical knowledge of the technical areas of the IRD.

The multidisciplinary and interdisciplinary nature of IRD requires the mastery of specific knowledge to achieve the IRD's strategic objectives. In that regard, employees who have critical knowledge are been encouraged to record and disseminate information for the benefit of the institution's long-term sustainability, although it is recognized that tacit knowledge, intrinsic to an activity or process, can be difficult to capture and transmit.

Another major challenge is that the lack of replacement of employees also makes it difficult to find people to whom knowledge can be transferred through mentoring, as well as other KM activities. In this sense, HR process can be improved by encouraging the use of KM tools to map profiles and planning for capacity building to the existing workforce, as well as, together with other sections, propose other strategies to mitigate the loss of knowledge, while recruitment of new workers is not possible. Thus, some KM activities that are already being implemented to improve the human resource development are Workforce Planning; Succession Planning; Risk Assessment for critical knowledge loss; Job Profiles or equivalent to assess and monitor skills/competency and supportive training and learning environment; Concept Mapping; Communities of Practice (CoPs) and Coaching and Mentoring.

It is intended to expand the activities of KM at IRD, such as the continuity of KMAV, the execution of projects and the offer of training in the area. As perspectives, it is expected the execution of the second stage of KMAV – level 2 in 2023; the definition of first pilot projects with consequent use of lessons learned for expansion throughout the IRD; the insertion of the KM in the master plan and institutional management; the inclusion of the KM program with the ISO quality standard; The development of indicators (KPIs); Organize and conduct workshops to provide an overview of national and international experience in NKM, as well as present activities to improve the execution of tasks related to NKM with the IRD team; and Holding of the 2nd Nuclear School of Knowledge Management in Brazil in 2024.

The support offered by the top management of the IRD should be highlighted, which has made it possible to carry out activities related to the implementation and effectiveness of KM in the IRD. In general, it can be said that in a culture where knowledge is power, many are still afraid of losing their space and, therefore, may not be concerned about transferring the knowledge acquired through years of work, which ends up making it difficult the KM process a bit.

At a strategic level, actions are being developed to promote a culture of knowledge transfer to future generations of employees, and it is increasingly important that regulatory agencies in their respective countries work with the IAEA through courses, training and meetings to assess the implementation and efficiency of KM programs.

Finally, as for the models used and applied by the IAEA, they are easy to understand, the results are easy to evaluate and free, with all documents available on the IAEA website. As expected, KM tools shows its potential to detect and quantify issues to be addressed and prioritized by institutional decision makers.

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